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SONAR ENUMERATION OF PACIFIC SALMON INTO NUSHAGAK RIVER, 1993

By

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ABSTRACT

Estimates of Pacific salmon *Oncorhynchus* escapement for the Nushagak River in Bristol Bay, Alaska, were determined by hydroacoustic procedures from June 4 through August 25, 1993. The escapement was sampled with drift gillnets and beach seines to estimate species composition, age, sex, and size. Final escapement estimates by species through August 25 were 715,099 sockeye salmon *O. nerka*, 97,812 chinook salmon *O. tshawytscha*, 217,230 chum salmon *O. keta*, and 42,742 coho salmon *O. kisutch*.

KEY WORDS: Pacific salmon, sonar, Nushagak River, Bristol Bay, escapement, estimation, fisheries management, *Oncorhynchus*

INTRODUCTION

The Nushagak River is located in southwestern Alaska (Figure 1) and flows approximately 390 km from its headwaters into Nushagak Bay in Bristol Bay, Alaska. Two main tributaries -- Nuyakuk River and Mulchatna River -- converge to form the Nushagak River. These rivers support large populations of five species of Pacific salmon *Oncorhynchus* which are harvested in commercial, sport, and subsistence fisheries. Accurate escapement estimates into this system are essential to fishery management.

In 1979, the Alaska Department of Fish and Game (ADF&G) began to examine the feasibility of using hydroacoustic (sonar) equipment and procedures to count adult salmon in Nushagak River (McBride 1981). During subsequent years, the Nushagak River sonar project has provided information important to the management of commercial fishing in Nushagak District.

Estimating numbers of salmon migrating into Nushagak River with sonar involves (1) estimating the number of hydroacoustic targets passing through sonar beam(s), (2) estimating the species composition of those targets by sampling the escapement, and (3) combining estimates of hydroacoustic targets and species composition to estimate numbers of passing salmon by species. During the initial years of the project, many changes were incorporated into the sonar and escapement sampling methods (McBride and Mesiar 1981, 1982; Minard 1983, 1985; Minard and Frederickson 1983). Few changes have been made in sonar operations since 1985, but changes have been made in the escapement sampling methods through the years (Morstad and Minard 1986, 1988; Bue 1988a, 1988b; Woolington and Bue 1989; Woolington and Miller 1992). Brannian et al. (*in press*) evaluated escapement sampling and the associated species apportionment methods used on Nushagak River during 1991 and compared them with methods used on the Lower Yukon River. Based on their project review, new methods of estimating Nushagak River salmon passage by species were incorporated in 1992 (Miller et al. *in press*).

Project objectives in 1993 were to estimate from early June through late August the spawning escapements for chinook, sockeye, chum, and coho salmon and to estimate the age, sex, and size composition of these escapements. Pink salmon return in even years only.

METHODS

The sonar enumeration site was located on Nushagak River, approximately 60 km upstream from the city of Dillingham and 4 km downstream from the village of Portage Creek (Figure

1). This area was chosen because it is the only place in the lower Nushagak River where the entire river is contained within one channel approximately 300 m wide. The current site was also chosen because stock identification studies (McBride and Mesiar 1981) indicated that the majority (93%) of the fish migrating past Portage Creek were destined for the Nushagak, Mulchatna, or Nuyakuk Rivers. Therefore very few fish migrating through the sonar would be stray fish from other rivers which might migrate downstream at a later date.

Hydroacoustic Counting

Sonar equipment used on Nushagak River included four Bendix Corporation[2] side-scanning salmon counters. Design characteristics of Bendix counters were described in King and Tarbox (1989). Gaudet (1983) provided a detailed description of sonar equipment use and procedures for counting salmon. Inshore and offshore counters were installed on the right and left (looking downstream) river bank. Inshore counters divided the counting range into 12 sectors; offshore counters divided the counting range into 16 sectors. All counters operated at 515 kHz with a pulse width of 100 μs. Counting range, pulse repetition rate, and sensitivity were adjustable.

Counting ranges of the equipment and placement and number of transducers were determined by the river bottom contour (Figures 2, 3). The river bottom at the right and left banks sloped downward toward the middle of the river at an even rate for 15 to 20 m, then sloped away at a steeper rate. Because of this bottom configuration, two transducers (inshore and offshore) were used on each side of the river. Offshore transducers, located where the bottom contour changed, counted outward. Inshore transducers were deployed within 10 m of shore in water of sufficient depth for fish passage and counted out to the offshore transducer.

Transducers were mounted on metal tripods and oriented to count the lower portion of the water column. Minard (1985) determined that over 88% of the fish occupied the lower two-fifths of the water column. With the aid of an oscilloscope, all transducers were aimed with the sonar beam tangent to the river bottom, maximizing ensonification of passing fish. Offshore transducers were aimed with remote-controlled pan and tilt rotators, whereas inshore transducers were aimed by manually adjusting the angle of the transducer mounts on the tripods. A weir was constructed from the shore to just beyond the inshore transducer on both river banks to prevent fish from passing behind the transducers or within approximately 1 m of the transducer face, an area in which the system may not detect fish.

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[2] Mention of a product name does not constitute endorsement.

Pulse repetition rate was adjusted on each counter to maintain counting precision at ±90% using calibration procedures described by Minard and Frederickson (1983). Counters were calibrated by comparing counts recorded by a sonar counter to those recorded by a trained technician observing an oscilloscope pattern of the signal generated by that counter. Counts from the oscilloscope were hand tallied for either a 10-min period or 100 counts, whichever came first. At the end of the counting interval, the machine count was divided into the oscilloscope count to yield a percent agreement between the two. If the percent agreement was less than 90% or greater than 110%, the pulse repetition rate was adjusted until an acceptable percent agreement was achieved. Counters were calibrated throughout the day between 0600 and 2400 hours. Frequency of calibrations was somewhat dependent upon fish passage rates and the variability of fish swimming speeds; there was at least one calibration per hour during periods of peak fish passage.

Sonar count data were summarized by sector, counter location (inshore, offshore, left or right bank), hour, and day to evaluate spatial and temporal distributions of sonar counts.

Escapement Sampling for Species Composition

Daily sonar counts were apportioned among salmon species based on species proportions in samples collected with a 45.7-m (25 fathom) beach seine and 18.3-m (10 fathom) drift gillnets with mesh sizes of 20.6 cm (8.125 in), 15.2 cm (6.0 in), and 13.0 cm (5.125 in). All gillnets were approximately 6 m deep. Twine size and color varied among mesh sizes depending solely on commercial availability. We sampled with beach seines just upstream and gillnets just downstream of the transducers so that catches represented the relative abundance of fish passing through the sonar beams. Because of the possibility that species composition was different between the inshore and offshore counting ranges, separate samples were taken: beach seines and gillnets for inshore and gillnets alone for offshore strata. Inshore drifts with gillnets were started with one end on the bank, while offshore drifts were started with the near shore end of the net approximately the same distance from shore as the offshore transducer.

The 15.2 and 13.0-cm mesh gillnets were fished for the entire season (June 7 - August 22), while the 20.6-cm mesh was fished only during the period of major chinook salmon passage (June 7 - July 28). Each gillnet mesh was fished for a minimum of two drifts inshore and two drifts offshore on each bank during each set of drifts. During the period of peak fish passage (June 20 - July 15), drift sessions were conducted three times daily: morning (0700 - 1100 hours), mid-day (1300 - 1700 hours), and evening (1800 - 2200 hours). Prior to June 19 and after July 15, drift sessions were conducted twice daily: mid-morning (0800 - 1000 hours) and early evening (1600 - 1800 hours). Drifts were not conducted at night because poor light conditions would make it impossible to maintain a drift within assigned strata. The maximum number of drifts conducted for each mesh size along each bank's inshore and

offshore strata was six per day.

Data recorded for each gillnet drift included (1) date, (2) drift session number (1 = morning, 2 = afternoon, 3 = evening), (3) boat operator, (4) drift number sequentially ordered through the season, (5) mesh size, (6) right or left river bank, (7) inshore or offshore counting ranges, (8) net length in fathoms, (9) fishing time, (10) number and species of catch, (11) length of each fish caught, mid-eye to fork-of-tail to nearest millimeter, and (12) sex as determined from external characteristics. The following fishing times were determined and recorded using a stopwatch for each drift:

Time net full out (*FO*) - Min:Sec
Time net started in (*SI*) - Min:Sec

Gillnet sampling data were entered into an Rbase[3] database.

When the fish passage rate on the right or left bank equaled or exceeded 1,000 fish/h, beach seines were used to sample inshore strata, whereas gillnets were used to sample offshore strata. For these days of high fish passage, at least three beach seine hauls per bank were conducted. The duration of a haul was not recorded because a unit of effort has not been defined for beach seining.

Species Composition Estimation

Daily estimates of fish by species were based on escapement samples and sonar count data. A program written in SAS[2] (1988) for use on the Yukon River (Fleischman et al. 1992) was modified to analyze Nushagak River data. Daily sonar counts were apportioned to species by bank and counting range. Four area strata were defined (1=left inshore, 2=left offshore, 3=right inshore, 4=right offshore). Catch per unit effort (CPUE) was used to calculate species proportions. Catch per fathom hour was estimated for all species of salmon (chinook (1), sockeye (2), coho (3), pink (4), and chum (5) salmon), humpback whitefish *Coregonus pidschian* (6), and a category for "other" (7; includes northern pike *Esox lucius*, rainbow trout *Salmo gairdneri*, and Arctic char *Salvinus alpinus*).

No adjustments for net selectivity among species were made. Brannian et al. (*in press*) and Miller et al. (*in press*) concluded that in order to adjust for selectivity, selectivity curves must be estimated using fish length or girth data obtained from escapement samples on the Nushagak River. Selectivities of gillnets used at the Nushagak River sonar site are currently under review. Only three years of Nushagak River selectivity data are available at this time,

[3] Mention of product name does not constitute endorsement.

and additional years are required to estimate accurate selectivity curves.

To estimate fishing effort, fishing time (FT) was calculated for each drift:

$$FT = SI - FO \quad . \tag{1}$$

The number of fathom hours (FH) was also calculated:

$$FH = \frac{f\,FT}{60} \quad , \tag{2}$$

where f was net length in fathoms (generally 10).

CPUE for each salmon species (group) was based on a subset of gillnet meshes fished. The combination of mesh sizes used to estimate the proportion of each species group was specified. CPUE for each species group i on day j in strata k was calculated by summing across the number caught (C_{ijkmn}) with mesh size (m) and drift (n):

$$CPUE_{ijk} = \frac{\sum_{m=1}^{3} \sum_{n=1}^{6} u_{im}\, C_{ijkmn}}{\sum_{m=1}^{3} \sum_{n=1}^{6} u_{im}\, FH_{jkmn}} \quad , \tag{3}$$

where u_{im} equals 1 if species i from mesh m is used to estimate species composition, and u_{im} equals 0 otherwise.

CPUE were cumulated across days to create a time (t) and area stratified estimate of species composition. The duration of a time stratum (report period) varied by range and bank and was specified as an input file. The desired sample size for each time-area strata was 100 salmon. Based on Thompson's (1987) "worst case" parameter value for a multinomial distribution, a sample size of 100 salmon would result in simultaneously estimating the proportion for each species within 10% of the true proportion 90% of the time. Even if (1) there was a departure from the assumption underlying a multinomial

distribution or (2) our use of raw catches, instead of CPUE data, decreased the likelihood of reaching the desired level of precision and accuracy, we felt that the 100-fish minimum sample size struck a balance between making strata too short to provide meaningful estimates of species composition and making strata so long that they failed to reflect seasonal changes in species composition. If < 100 salmon were captured during a day in an area strata, catches from the same gear type from subsequent days were accumulated until 100 salmon were obtained to define a reporting period. CPUE was used to estimate the proportion of species i in report period t and area strata k:

$$CPUE_{itk} = \sum_{j \in t} CPUE_{ijk} \quad . \tag{4}$$

Estimates of the proportion (S_{itk}) of species i for report period t and area strata k became

$$S_{itk} = \frac{CPUE_{itk}}{\sum_{i=1}^{7} CPUE_{itk}} \quad . \tag{5}$$

In order to estimate the variance of the S_{itk}, we generated replicate species proportion estimates (S_{ijk}) for each day j within report period t, S_{itk} then became a weighted mean of the S_{ijk}, where the weights are the total (all species) CPUE during day j of report period t. Variance of the S_{itk} were calculated after Cochran (1977 p 66) as

$$V(S_{itk}) = \frac{1}{J} \sum_{j \in t} \left(\frac{\sum_{i=1}^{7} CPUE_{ijk}}{\frac{1}{J} \sum_{j=1}^{J} \sum_{i=1}^{7} CPUE_{ijk}} \right)^2 \left(\frac{(S_{ijk} - S_{itk})^2}{(J-1)} \right) \quad . \tag{6}$$

This variance estimator treats daily catches as clusters of fish (adjusted for unequal effort) sampled randomly from all fish passing by the site during report period t. The estimator accounts for the unequal size of the clusters by the weighting factor. Ideally, we should have treated the fish caught during each *set* of drifts (two or three sets per day) as clusters, and generated replicate species proportions for each set. However the program was not modified to use individual drift sets in 1993.

If beach seining occurred on a particular day and at least 100 salmon were caught, it would

supersede any gillnet data for that area strata. Otherwise, catch data were pooled across several days of beach seining to obtain at least 100 salmon or were just ignored, in which case gillnet data were used. Species proportion estimates for the beach seine were based on the ratio of the number of species i caught (C_{itk}) to total catch for report period t and area strata k:

$$S_{itk} = \frac{C_{itk}}{\sum_{i=1}^{7} C_{itk}} \quad . \tag{7}$$

Variance was estimated using equation (6) through substituting C_{ijk} for $CPUE_{ijk}$.

Salmon Escapement Estimation

Sonar counts for each area strata (right and left bank, inshore and offshore) were apportioned to species on a daily basis. Daily estimates for each salmon species and area strata (N_{ijk}) were based on estimates of species proportions (S_{itk}) from escapement sampling and daily sonar counts (n_{jk}):

$$N_{ijk} = S_{itk} n_{jk} \quad where\ j \in t \ . \tag{8}$$

Daily escapement by species was estimated by summing area strata estimates:

$$\hat{N}_{ij} = \sum_{k=1}^{4} N_{ijk} \quad . \tag{9}$$

The daily estimate of variance became

$$V(N_{ij}) = \sum_{k=1}^{4} n_{jk}^2 V(S_{itk}) \quad where\ j \in t \quad . \tag{10}$$

Cumulative numbers of salmon were estimated by summing daily estimates, and the variance

was a sum of daily variances. This variance is conservative because some periods are a single day having a variance of zero.

Spatial Differences in Species Composition

The installation of two transducers on each bank (right in 1985 and left in 1989) established inshore and offshore counting ranges that could be treated separately in the estimation of species composition. We assumed that species composition differed by range and bank. This year's data were again collected by bank and range with the objective of testing the hypothesis that species composition did not differ between counting ranges within each bank. Chi-square tests for contingency tables were used to test these hypotheses. Drift gillnet catches were stratified through time to account for the differences in migratory timing among salmon species. Catch data for each time strata were classified simultaneously by species and range (or bank) into a two-way contingency table. Length of the time strata varied to incorporate overall sample sizes of 140 to 180 fish in order to guarantee a power (1-ß) >0.8 for 2 or 3 df when $\alpha = 0.01$ and medium effective size (ES) of 0.3 based on Tables from Cohen (1988). The Bonferroni inequality (Mendenhall et al. 1986) was applied to set a significance criterion at 0.01 to allow for an overall significance level of 0.1 as multiple tests (maximum 10) were conducted.

Age, Sex, and Size Sampling

Age, sex, and size (AWL) data were collected from chinook, sockeye, chum, and coho salmon migrating past the sonar site. Only sockeye and chum salmon captured with beach seines were sampled for AWL data to avoid size-selectivity associated with gillnets. All chinook and coho salmon captured were sampled to increase the number of AWL samples.

Age was determined by examining scales (Mosher 1968). Scales were collected from the left side of the fish approximately two rows above the lateral line in an area crossed by a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Because of the high rate of scale regeneration among chinook and coho salmon, three scales were collected from each fish. Only one scale per fish was collected from sockeye and chum salmon. Scales were mounted on gummed cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). We used European notation (Koo 1962) to record ages: numerals preceding the decimal refer to the number of freshwater annuli and numerals following the decimal refer to the number of marine annuli. Total age from time of egg deposition, or brood year, is the sum of these two numbers plus one to account for incubation time.

Sampling goals by species for the entire season were 1,200 sockeye, 600 chinook, 400 chum, and 250 coho salmon. The desired level of accuracy and precision for sockeye and chinook salmon age composition was 0.05. Based on Thompson's (1987) work, a sample size of 510 readable scales would simultaneously estimate the major age class within 5% of the true percentage 95% of the time. A sample size of 600 per strata was set for sockeye and chinook to account for regenerated and unageable scales. Two time strata were desired for sockeye salmon, therefore the goal for the season was set at 1,200. A sample size of 400 chum and 250 coho salmon scales ensured simultaneously estimating each major age class within 5% of the true percentage 90% of the time.

Salmon were measured from the middle of the eye to the fork of the tail and lengths were recorded to the nearest millimeter. Sex was determined from external characteristics.

Migratory Timing

Average proportions of salmon passage by day for each species were calculated using all years that sonar data were available. Average daily proportions ($\bar{p}_j$) were calculated by summing daily proportions for all years available ($\bar{p}_{ji}$) and dividing by total years (Y):

$$\bar{p}_j = \frac{\sum_{i=1}^{Y} p_{ji}}{Y}$$

Average cumulative proportions by day were calculated by summing the average daily proportions through time.

The 1993 runs by species were compared to their desired goals at the sonar site through time by applying historic migratory timing to the goals. The average daily cumulative proportions for each species were multiplied by their respective escapement goals (550,000 for sockeye salmon, 75,000 for chinook salmon, 350,000 for chum salmon, and 100,000 for coho salmon).

RESULTS

Hydroacoustic Counting

Counting began in each stratum on June 4. Counting ended on August 24 in right and left bank offshore counting ranges and on August 25 in right and left bank inshore counting ranges. A total of 1,076,393 counts were recorded (Table 1).

Gear Placement

Water level changes during project operation necessitated occasional repositioning of transducer tripods and adjustments of counting ranges (Table 2). The right bank inshore transducer counting range varied between 4.3 and 12.2 m, and the offshore transducer counting range varied between 12.2 and 16.8 m (Figure 2). Combined right bank counting range fluctuated between 20.4 and 24.4 m. The left bank inshore transducer ensonified between 6.2 and 10.7 m of river, and the left bank offshore transducer ensonified between 12.8 and 16.2 m (Figure 3). Combined left bank counting range varied between 20.0 and 26.9 m. Total ensonification for the right and left banks combined ranged from 42.3 to 49.6 m, or approximately 15% to 18% of the total river width.

Spatial Distribution of Sonar Counts

Throughout project operation, slightly fewer counts occurred on the right bank (513,034) than on the left bank (563,891; Table 1). Most sonar counts for the right (89%) and left (85%) banks were recorded by the inshore sonar counters (Miller et al. 1994).

Differences in run timing among species allowed us to look at spatial distributions of sonar counts during two separate time periods. Sockeye, chinook, and chum salmon were present primarily from the beginning of project operation (June 4) through July 25. Coho salmon were the primary species present after July 25.

June 4 - July 25. During the period of sockeye, chinook, and chum salmon passage, most counts in the right and left bank offshore strata were recorded within the first half of the counting range. The last four sectors of the right bank offshore area accounted for 5.1% of the right bank offshore counts and only 0.5% of the right bank inshore and offshore combined counts. The last four sectors of the left bank offshore area accounted for 15.4%

of the left bank offshore counts and 2.1% of the left bank inshore and offshore combined counts.

Distribution of sonar counts by sector were similar for both right and left bank inshore counting ranges (Figures 4, 5). Several peaks in sonar counts occurred between June 24 and July 3 in the right and left bank inshore counting ranges. The largest peak in both strata occurred on June 28. Most counts in both strata were observed in the middle of the counting range with fewer counts occurring at the inshore and offshore ends.

Sonar count distribution was also similar between the right and left bank offshore counting ranges (Figure 4, 5). Several peaks in sonar counts occurred in both strata between June 24 and July 5. Additional peaks occurred on June 7 and 16 in the right bank offshore stratum and on June 6 and 17 in the left bank offshore stratum. Most of the sonar counts in both strata were observed in the first half of the counting range. The left bank offshore stratum, however, had more counts occurring at the end of the counting range than did the right bank offshore stratum. This corresponds with the occasional observation by the sonar crew of chinook salmon "finning" the water surface out beyond the counting range of the left bank offshore transducer. Based on the distribution of left bank offshore sonar counts, it is probable that some fish were passing the sonar site beyond the range of the sonar beam.

July 26 - August 25. Few counts were observed at the end of the offshore counting ranges during the period of coho salmon passage. The last four sectors of the right bank offshore area accounted for 12.7% of the right bank offshore counts and 1.6% of the right bank inshore and offshore combined counts. The last four sectors of the left bank offshore area accounted for 6.2% of the left bank offshore counts and only 0.1% of the left bank inshore and offshore combined counts.

During this time period a major peak in sonar counts occurred on August 19 (Table 1; Figures 6, 7). Count distribution by sector indicated that most counts observed on this day in the right bank inshore stratum were recorded within the first half of the counting range. Count distribution for this day in the left bank inshore stratum was more varied. A second peak in sonar counts was observed earlier on August 7 in the left bank inshore range. Most counts observed in the left bank inshore area on this day occurred in the outer half of the counting range.

Peak days of passage in offshore ranges occurred around August 7, 15, and 19 (Figures 6, 7). Fewer counts were observed in the right bank offshore range than in the left bank offshore range. Count distribution by sector was also more variable in the right bank offshore range. Most counts in the left bank offshore range were observed within the first eight sectors.

Temporal Distribution of Sonar Counts

Information on patterns of hourly fish passage are of interest to determine optimal times for test fishing and equipment calibration. Any or all of a combination of variables such as tide, weather (winds, rainfall, etc...), and hours of daylight, as well as the time, date, and duration of commercial fishing periods might influence when migrating fish would pass the sonar site. In the right and left bank inshore and left bank offshore counting ranges, count distribution varied between days and no clear pattern of hourly fish passage was evident (Figure 8). Hourly count distribution in the left bank offshore stratum, however, indicated that fish passage was lower during the night and higher during daylight hours with peak passage occurring around 1400.

Escapement Sampling Catch and Effort

A total of 3,410 gillnet drifts were completed in 1993 (Miller et al. 1994). The 20.6-, 15.2-, and 13.0-cm mesh gillnets caught 486, 1,221, and 1,387 salmon, respectively. The total gillnet catch of 3,112 fish was composed of 924 chinook salmon, 1,363 sockeye salmon, 588 chum salmon, 219 coho salmon, and only 16 whitefish and "other" fish. The salmon catch was similar for the right inshore (890), left inshore (866), and left offshore (852) strata. The right offshore stratum had the smallest salmon catch (488). Beach seines were fished from June 23 through July 6 (Miller et al. 1994). A total of 4,176 salmon, mostly sockeye (3,340) and chum (810), were caught in 95 beach seine sets. Only 26 chinook salmon were caught in beach seines.

Beach seines caught the greatest number of sockeye salmon (3,340), followed by 13.0-cm mesh gillnets (646), 15.2-cm mesh (538), and 20.6-cm mesh (179) gillnets. Similarly, chum salmon were also caught predominantly in beach seines (810), followed by 13.0-cm mesh gillnets (303), 15.2-cm mesh (245), and 20.6-cm mesh (40) gillnets. Most chinook salmon were captured in gillnets, with similar numbers being caught between the 15.2-cm (330), 13.0-cm (327), and 20.6-cm (267) mesh gillnets. Only the 13.0-cm mesh and 15.2-cm mesh gillnets were fished during the period of coho salmon passage. Coho salmon catch was similar between the two mesh sizes with the 13.0-cm mesh catching 111 and the 15.2-cm mesh catching 108 coho salmon.

Durations of gillnet drifts ranged from 1.0 to 4.0 min. The average drift duration was 2.5 min (SE = 0.23).

Range Differences in Species Composition

Drift gillnet sampling data were divided into six periods between June 7 and July 31 (Table 3). Small sample sizes precluded comparisons after July 31. There were significant differences (α = 0.01) in species composition between inshore and offshore strata on the left bank for four of the five periods. These differences resulted from large catches of sockeye and chum salmon in the inshore strata and large catches of chinook salmon in the offshore strata. Significant differences in species composition between the right bank inshore and offshore ranges were found during three of the five periods. Differences on the right bank were the result of higher than expected catches of sockeye salmon in the inshore range. Chinook and chum salmon migrating on the right bank demonstrated no consistent preference between the inshore and offshore range.

Estimates of Escapement

Our final estimate of Nushagak River escapement in 1993 was 1,072,883 salmon. This included 715,099 sockeye, 97,812 chinook, 217,230 chum, and 42,742 coho salmon (Table 4). In addition, 1,400 whitefish and 2,110 "other" (northern pike, rainbow trout, and Arctic char) were counted passing the sonar site in 1993.

Sockeye Salmon

According to escapement sampling data, sockeye salmon began migrating past the sonar site on June 15 (Table 4). The 1993 escapement estimate of 715,099 sockeye salmon (S.E. = 6,444) was 130% of the 550,000 biological escapement goal.

Escapement timing of sockeye salmon in 1993 was early when compared with the 1980 - 1992 average escapement timing applied to the biological escapement goal (Table 5; Figure 9). Sockeye salmon were present at the sonar site from June 15 through August 9. Several peaks in sockeye salmon escapement were estimated from June 23 through July 8, with major peaks occurring on June 24 and 28 and July 3. Peak sockeye salmon passage occurred on June 28 with an estimate of 82,675.

Age and sex was determined for 1,939 sockeye salmon, 1,934 of which were also measured for length (Table 6). The most prominent age class was age-1.3 (1988 brood year) at 64%, followed by age-0.3 (1989 brood year) at 15% The male to female ratio was 1:1. Mean length by age ranged from 424 to 601 mm (Table 6).

Chinook Salmon

Chinook salmon were counted passing the sonar site immediately following installation of the sonar equipment (Table 4). The 1993 escapement estimate of 97,812 chinook salmon (S.E. = 5,581) was 130% of the 75,000 inriver escapement goal.

Escapement timing of chinook salmon in 1993 was early when compared to the previous nine years (Table 7; Figure 10). Chinook salmon were estimated at the sonar site from June 4 through August 9. Several peaks in chinook salmon passage occurred between June 7 and July 3. An early peak in chinook salmon passage was observed on June 7 with a daily passage estimate of 3,486; and the largest peak occurred on June 23 with an estimated passage of 10,830.

Age, sex, and length were determined for 833 chinook salmon (Table 8). Three major age classes were present: age-1.4 (45%; 1987 brood year); -1.3 (36%; 1988 brood year); and -1.2 (17%; 1989 brood year). The chinook salmon escapement was estimated to be 59% males and 41% females. Mean length by age ranged from 394 to 932 mm (Table 8).

Chum Salmon

As with chinook salmon, chum salmon were counted migrating past the sonar site the same day the sonar equipment was installed, June 4 (Table 4). There is no formal biological escapement goal for chum salmon in the Nushagak River, but the 1993 escapement estimate of 217,230 (S.E. = 4,558) was 62% of informal escapement objective of 350,000.

Escapement timing through June 26 appeared similar to the previous 13 year average (Table 9; Figure 11). After June 26, and throughout the remainder of the season, chum salmon escapement timing fell below the 13-year average. Peak chum salmon passage occurred on June 28 with an estimate of 23,874. Chum salmon were counted past the sonar site from June 4 through August 9.

Age and sex were determined for 641 chum salmon, 637 of which were measured for length (Table 10). Age-0.4 (64%; 1988 brood year) and -0.3 (31%; 1989 brood year) chum salmon predominated. The percentage of males and females were 54% and 46%. Mean length by age ranged from 558 to 600 mm (Table 10).

Coho Salmon

Escapement sampling data indicated that coho salmon began migrating past the sonar site

on July 26 (Table 4). The 1993 escapement estimate of 42,742 coho salmon (S.E. = 1,143) was only 43% of the 100,000 inriver escapement goal.

Coho salmon escapement timing in 1993 was well behind the previous 11 year average (Table 11; Figure 12). The peak day of coho salmon passage occurred August 19, with an estimate of 9,074 coho salmon. Subsequent to August 9 only coho salmon were present in escapement samples, so all sonar counts after this date were assumed to be coho salmon.

Age and sex were determined for 178 coho salmon, 176 of which were measured for length (Table 12). Age-2.1 (98%; 1989 brood year) and -3.1 (2%; 1988 brood year) coho salmon were the only two age groups present in the samples collected. The percentage of males and females were 48% and 52%. Mean length by age ranged from 548 to 590 mm (Table 12).

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Table 1. Inshore and offshore sonar counts by bank and day for the Nushagak River sonar project, 1993.

	Left Bank		Right Bank		
Date	Inshore	Offshore	Inshore	Offshore	Total
06/04	158	104	335	68	665
06/05	196	198	343	79	816
06/06	252	50	1,239	368	1,909
06/07	1,263	1,378	1,595	353	4,589
06/08	1,077	453	1,028	176	2,734
06/09	371	117	857	67	1,412
06/10	336	79	530	114	1,059
06/11	387	74	693	165	1,319
06/12	362	166	481	89	1,098
06/13	229	113	290	52	684
06/14	239	56	300	55	650
06/15	161	33	303	22	519
06/16	3,307	2,030	568	1,380	7,285
06/17	6,249	1,909	864	1,852	10,874
06/18	1,798	1,253	669	799	4,519
06/19	705	956	419	364	2,444
06/20	491	619	527	452	2,089
06/21	278	186	633	210	1,307
06/22	217	112	589	90	1,008
06/23	18,906	3,486	10,987	2,394	35,773
06/24	45,088	7,316	39,588	4,703	96,695
06/25	13,340	4,054	15,861	2,480	35,735
06/26	8,251	3,140	15,439	1,962	28,792
06/27	53,820	6,118	36,733	3,341	100,012
06/28	56,225	5,938	46,964	3,832	112,959
06/29	23,828	2,260	16,462	2,028	44,578
06/30	35,886	2,950	21,118	3,764	63,718
07/01	25,489	4,019	20,054	3,546	53,108
07/02	11,163	1,802	16,245	3,198	32,408
07/03	53,924	3,623	37,186	1,910	96,643
07/04	39,405	2,922	43,993	2,049	88,369
07/05	22,093	2,185	26,030	1,900	52,208
07/06	9,265	1,641	18,488	1,836	31,230
07/07	6,812	965	10,107	722	18,606
07/08	6,089	1,525	8,366	733	16,713
07/09	5,325	1,179	5,272	389	12,165
07/10	4,404	1,250	3,790	306	9,750
07/11	2,366	943	2,152	247	5,708
07/12	1,833	888	1,985	345	5,051
07/13	1,773	685	2,116	386	4,960
07/14	2,437	778	3,159	302	6,676
07/15	1,246	687	2,437	268	4,638
07/16	1,815	778	2,264	382	5,239
07/17	3,457	828	3,348	255	7,888
07/18	977	580	2,463	0[a]	4,020
07/19	1,261	550	2,021	0[a]	3,832
07/20	348	371	978	335	2,032
07/21	433	240	813	182	1,668
07/22	246	115	669	115	1,145
07/23	269	190	549	94	1,102
07/24	203	182	548	75	1,008
07/25	120	175	414	123	832
07/26	108	169	1,066	168	1,511
07/27	121	122	744	210	1,197
07/28	114	161	397	134	806
07/29	60	82	666	144	952

-Continued-

Table 1. (p 2 of 2)

Date	Left Bank Inshore	Left Bank Offshore	Right Bank Inshore	Right Bank Offshore	Total
07/30	69	123	698	174	1,064
07/31	107	65	350	46	568
08/01	313	52	524	60	949
08/02	98	86	810	48	1,042
08/03	96	154	300	106	656
08/04	94	170	776	193	1,233
08/05	113	223	1,097	237	1,670
08/06	87	81	464	126	758
08/07	1,333	996	1,920	319	4,568
08/08	625	476	818	213	2,132
08/09	158	155	304	100	717
08/10	55	83	437	86	661
08/11	57	18	228	62	365
08/12	64	111	452	70	697
08/13	129	88	419	175	811
08/14	101	62	491	192	846
08/15	115	625	320	419	1,479
08/16	86	841	662	97	1,686
08/17	94	280	621	54	1,049
08/18	60	202	455	96	813
08/19	785	1,274	6,853	161	9,073
08/20	292	328	3,341	190	4,151
08/21	157	99	848	25	1,129
08/22	51	78	528	37	694
08/23	90	6	294	25	415
08/24	61	9	263	8	341
08/25	25	0	94	0	119
Total	481,891	81,468	458,102	54,932	1,076,393

[a] Right bank offshore transducer was down for repairs from 1600 July 17 through 2400 July 19.

Table 2. Counting ranges for sonar counters on right and left banks, Nushagak River sonar project, 1993.

Right Bank				Left Bank			
Inshore		Offshore		Inshore		Offshore	
Date	Distance[a](m)	Date	Distance (m)	Date	Distance (m)	Date	Distance (m)
6/04	5.8	6/04 - 6/19	16.8	6/04	6.6	6/04	13.7
6/05 - 6/09	5.5	6/20 - 7/17 [b]	13.7	6/05 - 6/06	6.2	6/05 - 6/06	12.8
6/10	5.6	7/20 - 8/24	12.2	6/07 - 6/12	10.7	6/07 - 7/01	16.2
6/11	5.8			6/13 - 7/16	10.6	7/02	15.8
6/12	4.7			7/17 - 8/25	7.6	7/03	15.5
6/13 - 6/18	4.4					7/04 - 8/15	15.2
6/19	4.3					8/16 - 8/24	14.3
6/20	9.1						
6/21	8.8						
6/22 - 6/23	8.7						
6/24 - 6/30	8.5						
7/01 - 7/02	8.2						
7/03 - 7/16	8.4						
7/17 - 7/18	12.2						
7/19 - 7/20	10.1						
7/21 - 7/25	9.8						
7/26 - 8/13	9.9						
8/14 - 8/16	9.4						
8/17	8.2						
8/18 - 8/20	9.4						
8/21 - 8/25	9.1						

[a] Total distance from transducer that sonar beam was set to count fish.

[b] Right bank offshore counter down for repairs from 1600 July 17 through 2400 July 19.

Table 3. Chi-square test results comparing gillnet catches among inshore and offshore strata by period and river bank, Nushagak River sonar project, June 7 - July 31, 1993.

Period	River Bank	Chi-square	df	Approximate Probability of Larger Value
6/07-6/22	Right	2.630	2	0.269
	Left	1.405	2	0.495
6/25-6/26	Right	64.614	2	0.000[a]
	Left	130.887	2	0.000[a]
7/07-7/09	Right	15.716	2	0.000[a]
	Left	97.451	2	0.000[a]
7/10-7/14	Right	10.269	2	0.006[a]
	Left	94.541	2	0.000[a]
7/15-7/31	Right	0.014	2	0.993
	Left	32.639	2	0.000[a]

[a] Significant at α=0.01.

Table 4. Final daily and cumulative escapement estimates by species, Nushagak River sonar project, 1993.

	Sockeye		Chinook		Chum		Coho		Pink		Total	
Date	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
6 4	0	0	443	443	187	187	0	0	0	0	630	630
6 5	0	0	585	1,028	195	382	0	0	0	0	780	1,410
6 6	0	0	1,116	2,144	664	1,046	0	0	0	0	1,780	3,190
6 7	0	0	3,486	5,630	937	1,983	0	0	0	0	4,423	7,613
6 8	0	0	2,000	7,630	627	2,610	0	0	0	0	2,627	10,240
6 9	0	0	846	8,476	477	3,087	0	0	0	0	1,323	11,563
6 10	0	0	700	9,176	304	3,391	0	0	0	0	1,004	12,567
6 11	0	0	854	10,030	393	3,784	0	0	0	0	1,247	13,814
6 12	0	0	767	10,797	281	4,065	0	0	0	0	1,048	14,862
6 13	0	0	484	11,281	170	4,235	0	0	0	0	654	15,516
6 14	0	0	442	11,723	176	4,411	0	0	0	0	618	16,134
6 15	125	125	215	11,938	170	4,581	0	0	0	0	510	16,644
6 16	1,902	2,027	3,490	15,428	1,878	6,459	0	0	0	0	7,270	23,914
6 17	3,260	5,287	4,805	20,233	2,786	9,245	0	0	0	0	10,851	34,765
6 18	1,119	6,406	2,170	22,403	1,213	10,458	0	0	0	0	4,502	39,267
6 19	491	6,897	1,284	23,687	659	11,117	0	0	0	0	2,434	41,701
6 20	456	7,353	1,014	24,701	605	11,722	0	0	0	0	2,075	43,776
6 21	300	7,653	568	25,269	422	12,144	0	0	0	0	1,290	45,066
6 22	224	7,877	433	25,702	336	12,480	0	0	0	0	993	46,059
6 23	16,939	24,816	10,830	36,532	8,003	20,483	0	0	0	0	35,772	81,831
6 24	66,906	91,722	8,307	44,839	21,400	41,883	0	0	0	0	96,613	178,444
6 25	24,187	115,909	3,964	48,803	7,538	49,421	0	0	0	0	35,689	214,133
6 26	20,082	135,991	3,282	52,085	5,265	54,686	0	0	0	0	28,629	242,762
6 27	71,399	207,390	5,403	57,488	23,140	77,826	0	0	0	0	99,942	342,704
6 28	82,675	290,065	6,410	63,898	23,874	101,700	0	0	0	0	112,959	455,663
6 29	36,278	326,343	2,879	66,777	5,421	107,121	0	0	0	0	44,578	500,241
6 30	50,751	377,094	3,499	70,276	9,468	116,589	0	0	0	0	63,718	563,959
7 1	37,845	414,939	4,790	75,066	10,034	126,623	0	0	0	0	52,669	616,628
7 2	21,457	436,396	2,845	77,911	7,751	134,374	0	0	0	0	32,053	648,681
7 3	76,757	513,153	3,370	81,281	16,516	150,890	0	0	0	0	96,643	745,324
7 4	66,723	579,876	2,607	83,888	19,039	169,929	0	0	0	0	88,369	833,693
7 5	44,078	623,954	1,772	85,660	6,358	176,287	0	0	0	0	52,208	885,901
7 6	25,266	649,220	1,573	87,233	4,392	180,679	0	0	0	0	31,231	917,132
7 7	14,559	663,779	1,228	88,461	2,819	183,498	0	0	0	0	18,606	935,738
7 8	12,452	676,231	1,530	89,991	2,712	186,210	0	0	0	0	16,694	952,432
7 9	6,289	682,520	1,054	91,045	4,578	190,788	0	0	0	0	11,921	964,353
7 10	4,837	687,357	1,037	92,082	3,690	194,478	0	0	0	0	9,564	973,917
7 11	2,764	690,121	739	92,821	2,098	196,576	0	0	0	0	5,601	979,518

-Continued-

Table 4. (p 2 of 3)

Date	Sockeye		Chinook		Chum		Coho		Pink		Total	
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
7 12	2,678	692,799	683	93,504	1,612	198,188	0	0	0	0	4,973	984,491
7 13	2,725	695,524	555	94,059	1,600	199,788	0	0	0	0	4,880	989,371
7 14	3,239	698,763	627	94,686	2,696	202,484	0	0	0	0	6,562	995,933
7 15	2,161	700,924	392	95,078	1,995	204,479	0	0	0	0	4,548	1,000,481
7 16	2,436	703,360	455	95,533	2,263	206,742	0	0	0	0	5,154	1,005,635
7 17	3,824	707,184	533	96,066	3,409	210,151	0	0	0	0	7,766	1,013,401
7 18	1,891	709,075	321	96,387	1,719	211,870	0	0	0	0	3,931	1,017,332
7 19	1,803	710,878	311	96,698	1,644	213,514	0	0	0	0	3,758	1,021,090
7 20	908	711,786	208	96,906	878	214,392	0	0	0	0	1,994	1,023,084
7 21	776	712,562	141	97,047	720	215,112	0	0	0	0	1,637	1,024,721
7 22	554	713,116	73	97,120	494	215,606	0	0	0	0	1,121	1,025,842
7 23	501	713,617	106	97,226	475	216,081	0	0	0	0	1,082	1,026,924
7 24	455	714,072	99	97,325	433	216,514	0	0	0	0	987	1,027,911
7 25	363	714,435	94	97,419	359	216,873	0	0	0	0	816	1,028,727
7 26	44	714,479	27	97,446	13	216,886	1,427	1,427	0	0	1,511	1,030,238
7 27	35	714,514	21	97,467	15	216,901	1,127	2,554	0	0	1,198	1,031,436
7 28	23	714,537	19	97,486	13	216,914	752	3,306	0	0	807	1,032,243
7 29	27	714,564	16	97,502	8	216,922	902	4,208	0	0	953	1,033,196
7 30	28	714,592	20	97,522	9	216,931	1,006	5,214	0	0	1,063	1,034,259
7 31	21	714,613	9	97,531	10	216,941	527	5,741	0	0	567	1,034,826
8 1	45	714,658	11	97,542	29	216,970	864	6,605	0	0	949	1,035,775
8 2	35	714,693	16	97,558	10	216,980	982	7,587	0	0	1,043	1,036,818
8 3	18	714,711	17	97,575	11	216,991	611	8,198	0	0	657	1,037,475
8 4	33	714,744	25	97,600	12	217,003	1,163	9,361	0	0	1,233	1,038,708
8 5	45	714,789	33	97,633	15	217,018	1,578	10,939	0	0	1,671	1,040,379
8 6	23	714,812	13	97,646	10	217,028	712	11,651	0	0	758	1,041,137
8 7	181	714,993	101	97,747	126	217,154	4,160	15,811	0	0	4,568	1,045,705
8 8	82	715,075	48	97,795	60	217,214	1,941	17,752	0	0	2,131	1,047,836
8 9	24	715,099	17	97,812	16	217,230	660	18,412	0	0	717	1,048,553
8 10[a]	0	715,099	0	97,812	0	217,230	661	19,073	0	0	661	1,049,214
8 11[a]	0	715,099	0	97,812	0	217,230	364	19,437	0	0	364	1,049,578
8 12[a]	0	715,099	0	97,812	0	217,230	696	20,133	0	0	696	1,050,274
8 13[a]	0	715,099	0	97,812	0	217,230	811	20,944	0	0	811	1,051,085
8 14[a]	0	715,099	0	97,812	0	217,230	846	21,790	0	0	846	1,051,931
8 15[a]	0	715,099	0	97,812	0	217,230	1,480	23,270	0	0	1,480	1,053,411
8 16[a]	0	715,099	0	97,812	0	217,230	1,687	24,957	0	0	1,687	1,055,098
8 17[a]	0	715,099	0	97,812	0	217,230	1,049	26,006	0	0	1,049	1,056,147
8 18[a]	0	715,099	0	97,812	0	217,230	813	26,819	0	0	813	1,056,960

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Table 4. (p 2 of 3)

	Sockeye		Chinook		Chum		Coho		Pink		Total	
Date	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
8 19[a]	0	715,099	0	97,812	0	217,230	9,074	35,893	0	0	9,074	1,066,034
8 20[a]	0	715,099	0	97,812	0	217,230	4,151	40,044	0	0	4,151	1,070,185
8 21[a]	0	715,099	0	97,812	0	217,230	1,129	41,173	0	0	1,129	1,071,314
8 22[a]	0	715,099	0	97,812	0	217,230	693	41,866	0	0	693	1,072,007
8 23[a]	0	715,099	0	97,812	0	217,230	415	42,281	0	0	415	1,072,422
8 24[a]	0	715,099	0	97,812	0	217,230	342	42,623	0	0	342	1,072,764
8 25[a]	0	715,099	0	97,812	0	217,230	119	42,742	0	0	119	1,072,883
Total	715,099		97,812		217,230		42,742		0		1,072,883[b]	

[a] Coho salmon were the only fish present in test-fish catches after August 9, so all counts after August 9 are assumed to be coho salmon.

[b] An additional 1,400 whitefish and 2,110 other fish were counted passing the sonar site in 1993.

Table 5. Sockeye salmon escapement estimates and average escapement proportions by day, Nushagak River, 1980 - 1993.

	Year														Average Proportion[a]	
Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
06/04					149									0	0.01	0.01
06/05					457		0					74		0	0.02	0.04
06/06					574		0	0		2	11	126		0	0.02	0.05
06/07					591		3	0	2	4	11	94		0	0.02	0.07
06/08					622		2	0	3	3	32	80		0	0.02	0.08
06/09					624		3	0	11	14	145	74	0	0	0.02	0.10
06/10					450		15	0	25	19	33	114	0	0	0.01	0.11
06/11			0	253	385	19	6	0	18	9	23	79	0	0	0.02	0.13
06/12		243	0	335	254	5	15	0	5	23	15	87	0	0	0.02	0.16
06/13		457	0	454	362	42	71	0	6	25	52	75	0	0	0.03	0.19
06/14		420	120	282	787	48	76	0	4	23	37	71	0	0	0.03	0.22
06/15		323	252	437	1,440	7	32	0	106	25	149	866	0	125	0.06	0.28
06/16		573	239	297	1,528	6	37	0	185	24	117	2,360	0	1,902	0.10	0.39
06/17		1,514	614	282	3,478	4	16	332	71	78	51	836	0	3,260	0.14	0.52
06/18		972	678	306	1,380	8	14	540	50	114	43	770	0	1,119	0.09	0.61
06/19		893	481	292	2,519	82	112	301	41	21	47	443	915	491	0.09	0.70
06/20		1,247	338	790	1,544	3,124	141	217	65	64	0	677	1,132	456	0.18	0.89
06/21		5,134	0	606	1,019	2,616	88	115	27	361	0	860	1,811	300	0.20	1.08
06/22	352	3,426	7,133	3,385	3,030	915	119	145	28	1,082	995	1,457	1,594	224	0.39	1.47
06/23	476	2,490	23,182	1,653	3,475	1,698	229	154	50	1,372	5,297	3,088	951	16,939	0.78	2.25
06/24	528	239	39,230	5,455	11,295	369	270	740	54	3,460	1,960	10,144	999	66,906	1.79	4.04
06/25	737	0	7,133	2,890	83,644	229	1,091	3,275	8,697	15,260	1,009	11,286	1,379	24,187	2.06	6.10
06/26	1,339	0	0	3,749	54,222	419	3,392	4,456	19,752	36,432	320	10,463	20,836	20,082	2.29	8.40
06/27	1,670	195	8,916	4,125	48,318	421	4,282	2,145	15,167	24,731	355	8,926	35,478	71,399	2.73	11.13
06/28	268	1,701	21,398	9,926	14,201	305	1,583	4,039	16,237	14,893	1,540	11,075	32,522	82,675	2.74	13.87
06/29	111	3,287	14,266	4,826	18,904	908	853	16,046	5,819	3,495	1,935	29,203	14,576	36,278	2.05	15.92
06/30	3,688	6,143	16,049	7,235	44,465	1,400	946	47,423	2,392	37,613	1,604	15,961	18,597	50,751	3.52	19.44
07/01	25,625	76,193	41,014	9,534	31,261	53,282	5,874	66,559	1,466	34,028	9,858	62,496	12,759	37,845	6.58	26.01
07/02	104,306	41,641	37,447	9,224	58,296	35,792	9,468	84,275	1,708	57,488	85,624	30,292	5,701	21,457	7.43	33.44
07/03	240,530	52,501	35,664	4,781	22,133	18,234	5,414	39,477	4,345	55,416	55,341	88,577	3,239	76,757	7.55	40.99
07/04	294,491	82,221	32,098	8,079	8,840	13,382	18,067	19,411	45,767	106,391	23,207	100,822	19,927	66,723	8.94	49.93
07/05	222,282	223,247	30,314	28,917	37,884	13,210	34,648	9,143	42,967	15,922	8,977	35,766	22,121	44,078	8.25	58.19
07/06	97,701	150,089	37,447	10,492	55,571	16,440	44,969	5,523	10,097	14,731	34,852	4,094	63,871	25,266	6.05	64.24
07/07	54,034	25,267	23,182	7,959	15,876	12,124	57,760	5,930	11,032	19,106	314,041	2,228	71,122	14,559	6.88	71.12
07/08	23,484	22,271	24,965	8,792	14,680	21,881	46,419	18,647	11,348	12,635	56,812	1,641	36,090	12,452	3.89	75.01
07/09	9,973	22,068	5,350	6,926	14,618	19,258	41,217	22,710	52,969	5,812	10,124	1,306	12,242	6,289	3.16	78.17
07/10	9,223	42,360	7,133	5,818	15,366	10,439	104,907	2,918	57,393	9,242	4,864	1,809	9,580	4,837	3.35	81.52

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Table 5. (p 2 of 3)

Date	Year														Average Proportion[a]	
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
07/11	4,603	22,629	14,266	3,063	5,264	6,703	144,139	1,025	57,062	3,442	2,752	3,342	89,913	2,764	3.96	85.48
07/12	4,355	12,296	8,916	3,059	3,175	8,538	125,352	1,370	85,645	12,543	7,528	4,810	173,110	2,678	5.12	90.60
07/13	4,519	6,774	12,482	2,338	1,465	5,459	68,323	1,095	11,291	4,313	6,579	2,073	17,703	2,725	1.64	92.25
07/14	5,539	3,517	5,350	3,055	909	11,785	20,310	899	2,097	4,903	3,799	2,984	8,591	3,239	1.03	93.28
07/15	3,121	1,213	5,350	3,180	691	22,640	7,280	2,286	857	2,713	3,165	2,185	4,679	2,161	1.03	94.30
07/16	2,891	343	7,133	3,018	803	12,476	17,099	2,044	888	1,946	2,129	3,716	3,525	2,436	0.89	95.19
07/17	9,681		10,699	1,546	1,912	8,491	8,942	1,932	1,891	2,692	1,953	6,206	2,895	3,824	0.90	96.09
07/18	7,883		7,133	1,739	532	7,469	3,798	2,316	1,877	4,090	1,319	7,250	1,559	1,891	0.75	96.84
07/19	920		16,049	1,688	393	2,708	4,005	2,121	816	1,477	845	7,552	1,417	1,803	0.65	97.49
07/20	1,031		5,350	1,823	671	928	2,255	2,920	1,532	1,223	883	3,914	1,433	908	0.41	97.90
07/21	1,084		7,133	271	966	1,616	1,820	5,435	2,286	1,294	1,206	2,408	2,016	776	0.43	98.34
07/22	0		5,350	280	733	1,484	878	2,197	2,219	376	2,785	3,854	825	554	0.33	98.67
07/23	0		7,133	326	124	1,226	2,273	1,082	442	387	3,579	2,516		501	0.29	98.96
07/24	0		7,133	343	368	395	3,589	1,312	639	413	3,278	575		455	0.26	99.21
07/25	0		1,783	424	338	1,402	1,370	886	911	277	483	16		363	0.14	99.35
07/26	0		1,783	398	286	898	2,557	896	275	148	572	15		44	0.12	99.48
07/27	0		0	395	0	658	329	832	254	75	600	16		35	0.06	99.54
07/28	0		0	422	0	258	847	530	208	90	788	62		23	0.06	99.60
07/29	0		0	429	0	42	182	400	163	84	1,204	224		27	0.05	99.95
07/30	0		0	275	0	36	60	462	343	177	1,220	102		28	0.05	99.70
07/31	0		0	0	0	47	205	289	645	502	763	33		21	0.04	99.73
08/01	0		0	0	0	37	248	276	410	128	130	32		45	0.02	99.75
08/02	0		0	0	0	36	0	311	0	38	138	61		35	0.01	99.76
08/03	0		0	0	0	42	663	248	0	45	735	25		18	0.02	99.78
08/04	0		0	0	0	142	322	23	0	29	188	21		33	0.01	99.79
08/05	0		0	0	0	0	178	61	285	25	1,175	13		45	0.02	99.82
08/06	0		0	0	0	0	69	103	294	35	2,993	26		23	0.04	99.86
08/07			0	0	0	0	58	50	355	38	1,788	13		181	0.03	99.89
08/08			0	0	0	0	52	20	476	0	5,030	7		82	0.07	99.96
08/09			0	0	0	18	98	8	279	0	867	9		24	0.02	99.98
08/10			0	341	0	11	193	13	140	0	0	14		0	0.02	100.00
08/11			0	152	0	6	224	8	132	0	0	17		0		
08/12			0	125	0	26	123	11	211	0	0	22		0		
08/13			0	94	0	21	195	14	71	0	236	18		0		
08/14			0	73	0	37	67	7	79	0	177	24		0		
08/15			0	76	0	10	31	12	43	0	0	25		0		
08/16			0	66	0	5	38	9	36	0	0	8		0		
08/17			0	42	0	2		10	62	0	0	3		0		

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Table 5. (p 3 of 3)

	Year														Average Proportion[a]	
Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
08/18			0		0	2			31	0	0	5		0		
08/19					0	2			13	0	0	2		0		
08/20					0	3			9	0	0	3		0		
08/21					0	1			15	0	0	1		0		
08/22					0				6	0	0			0		
08/23					0				5	0	0			0		
08/24					0					0	0			0		
08/25					0					0	0			0		
Total	1,136,445	813,887	537,686	177,141	592,872	322,327	800,311	388,034	483,200	513,421	680,368	492,522	695,108	715,099		

[a] Average proportions for 1980 - 1993, June 4 through August 10.

Table 6. Age, sex, and size composition of sockeye salmon escapement, Nushagak River sonar project, 1993.

	Age Group									
	0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	Total
Sample Period 1: 15 - 27 June										
Males	3,148	2,361	6,690	2,361	75,164		7,084	394		97,202
Percent	1.52	1.14	3.23	1.14	36.24		3.42	0.19		46.87
Sample Size	8	6	17	6	191		18	1		247
Mean Length	430	584	432	618	580		613	592		569
Std. Error	5	21	10	13	3		6			2
Sample Size	8	6	17	6	189		18	1		245
Females		3,542	1,574	1,968	89,330		13,380		394	110,188
Percent		1.71	0.76	0.95	43.07		6.45		0.19	53.13
Sample Size		9	4	5	227		34		1	280
Mean Length		543	455	581	557		578		560	558
Std. Error		7	26	11	1		4			1
Sample Size		9	4	5	226		34		1	279
Both Sexes	3,148	5,903	8,264	4,329	164,494		20,464	394	394	207,390
Percent	1.52	2.85	3.98	2.09	79.32		9.87	0.19	0.19	100.00
Sample Size	8	15	21	11	418		52	1	1	527
Mean Length	430	560	437	601	568		590	592	560	563
Std. Error	5	9	9	9	1		3			1
Sample Size	8	15	21	11	415		52	1	1	524
Sample Period 2: 28 - 29 June										
Males	3,734	4,001	2,134	1,334	44,540		2,400			58,143
Percent	3.14	3.36	1.79	1.12	37.44		2.02			48.88
Sample Size	14	15	8	5	167		9			218
Mean Length	429	567	470	622	586		615			573
Std. Error	5	13	15	15	3		9			2
Sample Size	14	15	7	5	167		9			217
Females		4,534	1,334	2,134	48,540	267	3,734	267		60,810
Percent		3.81	1.12	1.79	40.81	0.22	3.14	0.22		51.12
Sample Size		17	5	8	182	1	14	1		228
Mean Length		548	526	583	559	530	580	561		560
Std. Error		4	24	8	1		5			1
Sample Size		17	5	8	182	1	14	1		228
Both Sexes	3,734	8,535	3,468	3,468	93,080	267	6,134	267		118,953
Percent	3.14	7.18	2.92	2.92	78.25	0.22	5.16	0.22		100.00
Sample Size	14	32	13	13	349	1	23	1		446
Mean Length	429	557	492	598	572	530	594	561		566
Std. Error	5	6	13	7	1		5			1
Sample Size	14	32	12	13	349	1	23	1		445

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Table 6. (p 2 of 3)

	Age Group									
	0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	Total
Sample Period 3: 30 June - 3 July										
Males	7,220	10,378	5,415	1,805	57,758	451	3,159	451		86,637
Percent	3.86	5.56	2.90	0.97	30.92	0.24	1.69	0.24		46.38
Sample Size	16	23	12	4	128	1	7	1		192
Mean Length	429	571	480	639	594	532	622	604		572
Std. Error	11	9	18	8	2		8			2
Sample Size	16	23	12	4	128	1	7	1		192
Females		16,696	4,061	5,866	65,879		7,220	451		100,173
Percent		8.94	2.17	3.14	35.27		3.86	0.24		53.62
Sample Size		37	9	13	146		16	1		222
Mean Length		553	511	581	560		590	598		561
Std. Error		3	9	5	2		5			1
Sample Size		37	9	13	146		16	1		222
Both Sexes	7,220	27,074	9,476	7,671	123,637	451	10,379	902		186,810
Percent	3.86	14.49	5.07	4.11	66.18	0.24	5.56	0.48		100.00
Sample Size	16	60	21	17	274	1	23	2		414
Mean Length	429	560	494	594	576	532	600	601		566
Std. Error	11	4	11	5	1		4			1
Sample Size	16	60	21	17	274	1	23	2		414
Sample Period 4: 4 July - 9 August										
Males	21,585	35,853	5,488	5,854	42,436	366	2,561	366		114,509
Percent	10.69	17.75	2.72	2.90	21.01	0.18	1.27	0.18		56.70
Sample Size	59	98	15	16	116	1	7	1		313
Mean Length	421	599	468	634	596	562	618	585		560
Std. Error	2	3	15	4	2		8			1
Sample Size	59	97	15	16	116	1	7	1		312
Females		31,463	6,585	11,341	33,657	366	3,293	732		87,437
Percent		15.58	3.26	5.62	16.67	0.18	1.63	0.36		43.30
Sample Size		86	18	31	92	1	9	2		239
Mean Length		554	501	589	556	523	581	574		556
Std. Error		2	7	4	3		9	10		2
Sample Size		86	18	31	92	1	9	2		239
Both Sexes	21,585	67,316	12,073	17,195	76,093	732	5,854	1,098		201,946
Percent	10.69	33.33	5.98	8.51	37.68	0.36	2.90	0.54		100.00
Sample Size	59	184	33	47	208	2	16	3		552
Mean Length	421	578	486	605	579	543	597	578		558
Std. Error	2	2	8	3	2		6	10		1
Sample Size	59	183	33	47	208	2	16	3		551

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Table 6. (p 3 of 3)

	Age Group									
	0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	2.4	Total
All Periods Combined:										
Males	35,687	52,593	19,727	11,354	219,898	817	15,204	1,211		356,491
Percent	4.99	7.35	2.76	1.59	30.75	0.11	2.13	0.17		49.85
Sample Size	97	142	52	31	602	2	41	3		970
Mean Length	424	590	459	630	588	545	616	594		567
Std. Error	3	3	8	4	1		4			1
Sample Size	97	141	51	31	600	2	41	3		966
Females		56,235	13,554	21,309	237,406	633	27,627	1,450	394	358,608
Percent		7.86	1.90	2.98	33.20	0.09	3.86	0.20	0.06	50.15
Sample Size		149	36	57	647	2	73	4	1	969
Mean Length		553	501	586	558	526	582	579	560	559
Std. Error		1	6	3	1		3	10		1
Sample Size		149	36	57	646	2	73	4	1	968
Both Sexes	35,687	108,828	33,281	32,663	457,304	1,450	42,831	2,661	394	715,099
Percent	4.99	15.22	4.65	4.57	63.95	0.20	5.99	0.37	0.06	100.00
Sample Size	97	291	88	88	1,249	4	114	7	1	1,939
Mean Length	424	571	476	601	573	537	594	586	560	563
Std. Error	3	2	5	2	1		2	10		1
Sample Size	97	290	87	88	1,246	4	114	7	1	1,934

Table 7. Chinook salmon escapement estimates and average escapement proportions by day, Nushagak River, 1980 - 1993.

	Year													Average Proportion[a]	
Date	1980	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
06/04													443	0.44	0.44
06/05											106		585	0.34	0.79
06/06						1	45		2	63	164		1,116	0.24	1.03
06/07						9	153	115	4	64	118		3,486	0.59	1.61
06/08						6	158	165	3	136	119		2,000	0.40	2.01
06/09						11	1,676	336	14	386	121	124	846	0.53	2.55
06/10						51	1,441	916	19	151	159	105	700	0.58	3.12
06/11				118	44	41	640	873	9	108	139	110	854	0.38	3.50
06/12		1,128		156	9	82	760	186	23	94	164	140	767	0.33	3.84
06/13		2,124		212	112	318	446	205	25	241	138	1,567	484	0.58	4.42
06/14		1,951	281	131	148	297	507	143	23	166	120	1,138	442	0.47	4.89
06/15		1,500	589	204	33	101	657	1,875	25	2,468	1,214	715	215	1.01	5.89
06/16		2,660	557	139	24	148	366	5,078	24	1,953	4,751	1,177	3,490	2.04	7.93
06/17		909	1,432	132	14	43	2,048	1,359	138	844	2,332	2,841	4,805	1.55	9.49
06/18		584	1,583	143	20	72	2,943	874	188	712	2,008	3,607	2,170	1.38	10.87
06/19		568	1,123	136	371	424	1,407	570	64	788	1,201	852	1,284	0.84	11.71
06/20		14	790	368	2,627	789	883	1,084	109	542	923	967	1,014	1.02	12.73
06/21		56	7,836	570	3,886	525	678	613	450	1,374	1,166	1,765	568	1.66	14.39
06/22	3,975	2,056	5,746	3,180	1,755	521	724	449	1,746	10,709	1,888	1,388	433	3.25	17.64
06/23	5,377	3,556	6,791	1,553	3,557	188	611	781	2,712	4,692	4,199	895	10,830	3.87	21.51
06/24	1,463	7,500	17,239	5,124	888	274	14,082	1,279	5,876	1,729	19,352	959	8,307	6.46	27.97
06/25	2,040	11,472	4,179	2,715	380	516	10,196	6,334	2,561	890	10,207	1,047	3,964	4.72	32.69
06/26	3,707	7,049	2,612	4,388	645	643	2,340	4,292	5,973	285	7,721	8,043	3,282	4.42	37.12
06/27	4,623	5,592	1,567	4,828	1,761	999	1,296	2,481	1,257	313	3,502	4,726	5,403	3.34	40.45
06/28	3,661	1,625	1,567	11,618	1,716	750	2,215	1,980	838	264	4,555	4,428	6,410	3.54	43.99
06/29	1,524	3,140	3,134	5,649	604	405	5,444	2,486	2,167	332	10,129	5,354	2,879	3.59	47.58
06/30	1,553	3,909	5,224	8,468	907	443	2,179	1,007	1,521	283	5,290	7,036	3,499	3.29	50.87
07/01	1,875	2,432	5,746	5,742	9,184	128	7,369	536	395	1,428	1,884	5,534	4,790	3.80	54.67
07/02	4,688	21,917	5,746	5,556	15,016	181	1,612	700	417	5,317	1,081	1,704	2,845	5.12	59.78
07/03	2,702	14,789	5,224	2,880	6,527	187	3,448	1,612	6	2,350	1,326	1,207	3,370	3.50	63.28
07/04	2,777	10,517	1,045	4,866	4,291	82	1,581	3,519	1,386	1,857	2,517	2,254	2,607	3.25	66.53
07/05	2,850	5,773	4,179	4,876	4,074	782	781	3,339	2,614	724	1,431	2,563	1,772	3.05	69.59
07/06	2,252	3,400	4,179	1,769	5,850	1,249	399	625	2,812	1,171	1,316	3,300	1,573	2.55	72.14
07/07	2,052	2,214	3,657	1,342	4,023	2,256	565	684	3,861	2,579	664	1,683	1,228	2.50	74.64
07/08	602	1,028	1,567	1,482	3,217	1,990	1,922	705	2,817	10,211	518	1,482	1,530	2.96	77.60
07/09	285	1,720	2,090	1,168	2,752	2,192	1,508	0	1,104	2,301	379	1,538	1,054	1.70	79.30
07/10	784	1,880	3,134	981	2,886	1,843	235	0	1,905	1,636	398	1,243	1,037	1.62	80.92
07/11	1,284	1,880	1,567	2,351	2,192	1,111	462	0	1,059	433	791	2,568	739	1.43	82.35
07/12	917	2,049	2,612	2,347	1,222	3,891	641	2,663	6,996	643	1,397	2,774	683	2.89	85.25
07/13	1,010	1,103	2,090	1,794	829	1,247	502	509	2,408	619	390	1,823	555	1.38	86.62

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Table 7. (p 2 of 2).

Date	Year													Average Proportion[a]	
	1980	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
07/14	1,108	959	2,090	2,345	1,880	1,447	407	724	1,591	447	468	1,074	627	1.40	88.02
07/15	624	934	4,702	2,440	4,016	3,045	1,074	296	2,527	179	386	725	392	1.95	89.97
07/16	662	264	1,567	755	2,000	1,166	937	307	2,070	157	543	698	455	1.08	91.05
07/17	2,689	0	2,090	387	1,718	3,097	890	653	2,186	281	838	512	533	1.70	92.75
07/18	5,101	0	2,090	435	1,631	1,146	1,069	648	3,628	243	953	431	321	1.79	94.54
07/19	595	0	522	422	2,389	1,176	947	282	1,420	25	1,117	317	311	0.92	95.45
07/20	0	0	1,045	456	951	936	743	529	1,828	30	637	211	208	0.73	96.18
07/21	0	0	522	361	493	738	1,399	788	1,619	51	531	177	141	0.68	96.86
07/22	0	0	1,567	373	477	398	509	766	795	114	1,245	46	73	0.56	97.43
07/23	0	0	522	435	371	288	224	89	728	127	580		106	0.31	97.73
07/24	0	0	1,045	458	119	808	269	102	1,106	131	177		99	0.43	98.16
07/25	0	0	1,500	566	522	463	168	229	748	364	19		94	0.42	98.58
07/26	0	0	2,090	597	319	618	157	91	452	208	20		27	0.40	98.98
07/27	0	0	0	592	234	1,168	158	78	317	94	18		21	0.33	99.31
07/28	0	0	0	633	104	120	90	111	372	531	62		19	0.20	99.51
07/29	0	0	0	644	29	0	68	79	327	37	244		16	0.12	99.63
07/30	0	0	0	413	17	182	77	142	517	22	207		20	0.16	99.79
07/31	0	0	0	957	27	60	51	87	1,098	12	47		9	0.21	100.00
08/01	0	0	0	660	26	50	44	95	474	0	34		11		
08/02	0	0	0	790	18	0	61	0	205	46	64		16		
08/03	0	0	0	734	24	0	47	436	362	0	31		17		
08/04	0	0	0	658	62	787	0	0	170	0	23		25		
08/05	0	0	0	55	0	381	0	0	59	0	18		33		
08/06	0	0	0	89	0	204	0	0	57	0	28		13		
08/07		0	0	83	0	87	0	0	95	0	12		101		
08/08		0	0	211	0	72	0	0	0	0	8		48		
08/09		0	0	232	0	66	0	0	0	0	11		17		
08/10		0	0	0	0	135	0	0	0	0	27		0		
08/11			0	0	0	0	0	0	0	0	28		0		
08/12			0	0	0	0	0	0	0	0	28		0		
08/13			0	0	0	0	0	0	0	0	14		0		
08/14			0	0	0	0	0	0	0	0	9		0		
08/15			0	0	0	0	0	0	0	0	8		0		
08/16			0	0	0	0	0	0	0	0	16		0		
08/17			0	0	0	0	0	0	0	0	7		0		
08/18			0		0	0	0	0	0	0	7		0		
08/19					0			0	0	0	3		0		
08/20					0			0	0	0	4		0		
08/21					0			0	0	0	1		0		
Total	62,780	130,252	126,438	103,767	98,991	43,434	84,309	56,905	78,302	63,955	104,351	82,848	97,812		

[a] Average proportions for 1983, 1985 - 1993, June 5 through July 31.

Table 8. Age, sex, and size composition of chinook salmon escapement, Nushagak River sonar project, 1993.

	Age Group						
	1.1	1.2	1.3	1.4	1.5	2.4	Total
Males	587	12,682	22,546	21,018	939	117	57,889
Percent	0.60	12.97	23.05	21.49	0.96	0.12	59.18
Sample Size	5	108	192	179	8	1	493
Mean Length	394	559	754	876	962	874	756
Std. Error	43	6	6	6	29		3
Sample Size	5	108	192	179	8	1	493
Females		4,227	12,447	22,897	352		39,923
Percent		4.32	12.73	23.41	0.36		40.82
Sample Size		36	106	195	3		340
Mean Length		571	782	861	854		806
Std. Error		8	8	5	37		4
Sample Size		36	106	195	3		340
Both Sexes	587	16,909	34,993	43,915	1,291	117	97,812
Percent	0.60	17.29	35.78	44.90	1.32	0.12	100.00
Sample Size	5	144	298	374	11	1	833
Mean Length	394	562	764	868	932	874	776
Std. Error	43	5	5	4	24		3
Sample Size	5	144	298	374	11	1	833

Table 9. Chum salmon escapement estimates and average escapement proportions by day, Nushagak River, 1980 - 1993.

	Year														Average Proportion[a]	
Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
06/04					100									187	0.06	0.06
06/05					305		0					110		195	0.05	0.11
06/06					383		1	9		2	35	183		664	0.07	0.18
06/07					394		8	19	65	128	36	144		937	0.08	0.26
06/08					415		5	22	94	149	88	124		627	0.07	0.33
06/09					416		6	152	205	103	322	119	253	477	0.09	0.42
06/10					300		37	150	545	112	94	170	275	304	0.09	0.51
06/11			0	0	257	3	8	63	501	11	66	124	178	393	0.06	0.57
06/12		364	0	0	289	0	25	127	112	31	51	135	245	281	0.06	0.63
06/13		686	0	0	328	9	139	68	123	44	149	117	2,377	170	0.13	0.76
06/14		630	100	0	524	17	166	53	85	106	104	112	1,719	176	0.12	0.88
06/15		485	210	0	960	6	79	57	2,650	71	2,191	1,211	993	170	0.28	1.16
06/16		859	199	0	1,018	4	80	37	5,774	127	1,691	3,354	2,308	1,878	0.57	1.72
06/17		330	512	0	331	2	40	786	1,839	127	747	1,169	6,097	2,786	0.46	2.18
06/18		212	565	0	1,380	1	25	1,313	1,241	180	618	1,024	7,379	1,213	0.45	2.63
06/19		162	401	0	504	66	245	751	924	48	665	627	2,014	659	0.23	2.86
06/20		95	282	0	309	6,283	220	553	1,579	103	1,627	941	2,552	605	0.49	3.35
06/21		391	3,895	487	29	3,209	126	274	764	1,377	4,766	1,190	4,256	422	0.64	3.99
06/22	704	3,084	3,895	2,718	19	1,414	235	357	666	4,053	61,168	2,159	3,587	336	2.09	6.08
06/23	953	2,845	1,948	1,327	2,824	2,846	509	394	1,181	5,035	13,549	4,678	2,177	8,003	1.35	7.42
06/24	2,072	239	7,790	4,380	7,530	703	757	8,520	1,549	12,896	5,180	37,121	2,302	21,400	3.25	10.67
06/25	2,890	1,275	5,194	2,321	13,207	310	6,649	24,484	37,375	13,309	2,668	13,765	2,926	7,538	4.51	15.18
06/26	5,252	2,106	14,282	2,939	26,651	531	7,461	9,730	24,871	37,152	787	12,980	70,205	5,265	5.91	21.09
06/27	6,550	715	12,335	3,235	23,750	1,354	9,871	4,533	6,206	19,834	942	10,142	30,632	23,140	4.23	25.32
06/28	5,001	454	10,387	7,783	67,031	1,306	12,630	8,737	6,181	11,501	152	12,072	16,697	23,874	5.15	30.47
06/29	2,081	876	1,948	3,784	89,225	347	6,843	2,225	1,784	12,653	190	20,662	12,895	5,421	3.82	34.29
06/30	1,229	1,117	7,790	5,673	17,242	541	7,480	16,250	750	14,558	137	11,025	15,892	9,468	3.38	37.66
07/01	3,750	2,432	9,738	1,733	10,212	18,749	2,843	26,278	551	17,800	37,878	5,882	11,160	10,034	4.68	42.34
07/02	8,204	9,497	7,141	1,677	8,093	27,024	4,135	12,608	556	23,527	28,403	4,831	9,766	7,751	4.44	46.78
07/03	27,026	6,655	21,424	869	17,438	9,186	2,117	5,688	1,607	25,766	23,937	20,793	5,105	16,516	4.82	51.60
07/04	60,317	2,868	6,492	1,469	6,965	6,889	2,568	2,335	8,898	35,698	6,148	57,021	3,530	19,039	5.51	57.12
07/05	59,845	4,556	5,194	8,238	11,430	6,848	7,630	1,246	7,069	11,076	2,364	17,481	3,769	6,358	4.26	61.38
07/06	36,136	4,642	2,597	2,989	4,015	8,293	3,154	472	2,746	9,763	19,729	1,546	6,620	4,392	2.81	64.19
07/07	12,312	32,159	3,246	2,267	9,355	6,201	1,128	440	2,981	12,403	19,224	936	13,819	2,819	3.73	67.91
07/08	6,021	10,964	9,089	2,505	7,234	7,338	4,644	1,311	3,053	7,878	28,154	739	5,901	2,712	2.85	70.76
07/09	3,989	4,872	3,895	1,973	3,765	6,601	5,551	2,532	1,135	7,435	6,448	559	3,023	4,578	1.76	72.53
07/10	2,755	11,948	7,141	1,657	2,561	5,348	11,008	574	6,152	11,640	10,333	780	2,362	3,690	2.54	75.07

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Table 9. (p 2 of 3)

Date	Year														Average Proportion[a]	
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
07/11	4,817	6,383	8,440	3,205	2,507	4,401	8,089	301	6,382	6,060	3,337	1,366	19,174	2,098	2.40	77.47
07/12	6,189	6,149	8,440	3,201	0	1,178	27,386	333	24,133	16,412	2,854	1,706	14,505	1,612	3.80	81.28
07/13	4,895	7,877	9,089	2,447	932	746	7,314	295	5,310	5,646	2,472	1,580	6,202	1,600	1.88	83.16
07/14	4,431	6,180	2,597	3,198	578	1,596	2,138	258	840	5,343	1,035	2,223	3,027	2,696	1.22	84.38
07/15	2,496	7,187	2,597	3,327	440	18,524	4,709	540	368	6,137	564	1,646	1,603	1,995	1.82	86.20
07/16	3,572	2,030	2,597	2,910	511	10,549	5,500	552	379	4,551	436	2,752	1,351	2,263	1.34	87.54
07/17	14,521		3,895	1,491	1,217	4,898	2,933	509	756	5,902	612	4559	1,225	3,409	1.35	88.89
07/18	31,534		7,141	1,677	5,322	4,215	1,223	606	667	9,144	496	5,325	614	1,719	1.86	90.75
07/19	3,680		5,843	1,628	4,716	20,261	1,284	650	296	3,366	651	5,615	550	1,644	1.61	92.36
07/20	4,122		8,440	1,758	1,343	5,744	1,481	1,037	531	4,094	702	2,938	548	878	1.09	93.44
07/21	4,334		2,597	1,174	3,381	5,687	1,136	1,876	742	4,173	1,011	1,876	755	720	0.92	94.36
07/22	0		1,948	1,214	2,565	5,002	695	954	728	1,375	2,313	3,217	290	494	0.68	95.04
07/23	0		1,298	1,413	62	4,338	752	561	913	1,371	2,872	1,973		475	0.61	95.65
07/24	0		2,597	1,488	184	1,403	1,178	690	1,258	1,322	2,703	471		433	0.54	96.19
07/25	0		2,597	1,839	169	358	661	513	1,985	891	2,641	67		359	0.50	96.69
07/26	0		2,597	1,989	143	219	161	564	797	510	2,495	68		13	0.41	97.10
07/27	0		2,597	1,974	117	160	354	480	723	317	2,265	73		15	0.39	97.49
07/28	0		1,948	2,109	74	71	120	341	691	375	4,130	256		13	0.41	97.90
07/29	0		649	2,146	159	20	0	259	525	249	601	978		8	0.28	98.18
07/30	0		649	1,377	239	11	922	303	1,054	483	525	376		9	0.28	98.46
07/31	0		649	957	663	18	305	180	1,602	1,279	318	153		10	0.25	98.71
08/01	0		0	660	0	18	0	190	1,102	375	447	161		29	0.14	98.84
08/02	0		3,246	790	0	12	0	174	489	126	46	334		10	0.22	99.06
08/03	0		0	734	0	16	0	142	436	0	269	149		11	0.10	99.16
08/04	0		0	658	258	43	641	161	156	0	557	123		12	0.12	99.28
08/05	0		0	73	0	122	310	478	205	0	828	79		15	0.08	99.37
08/06	0		0	118	0	174	155	686	170	0	3,290	159		10	0.16	99.52
08/07			0	110	0	110	80	260	248	0	1,863	92		126	0.10	99.63
08/08			0	281	0	472	65	101	945	62	5,102	48		60	0.24	99.87
08/09			0	309	0	445	62	45	175	568	896	61		16	0.10	99.97
08/10			0	0	0	172	141	47	0	549	0	70		0	0.03	100.00
08/11			0	0	0	206	58	31	0	136	0	82		0		
08/12			0	0	0	487	0	19	0	0	0	122		0		
08/13			0	0	0	260	0	21	0	0	297	114		0		
08/14			0	0	0	511	0	23	0	0	199	166		0		
08/15			0	0	0	231	0	38	0	0	47	177		0		
08/16			0	0	0	145	0	37	0	0	16	32		0		
08/17			0	0	0	71	0	30	0	0	97	13		0		

-Continued-

Table 9. (p 3 of 3)

Date	Year														Average Proportion[a]	
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Daily	Cum.
08/18			0		0	54			0	0	97	25		0		
08/19					0	54			0	0	68	12		0		
08/20					0	41			0	0	0	13		0		
08/21					0	9			0	0	0	4		0		
08/22					0				0	0	0			0		
08/23					0				0	0	0			0		
08/24					0					0	0			0		
08/25					0					0	0			0		
Total	331,678	143,324	230,141	106,279	362,369	214,481	168,276	147,433	186,418	377,512	329,793	287,280	302,858	217,230		

[a] Average proportions for 1980 - 1993, June 4 through August 10.

Table 10. Age, sex, and size composition of chum salmon escapement, Nushagak River sonar project, 1993.

	Age Group			
	0.3	0.4	0.5	Total
Males	31,856	80,656	5,761	118,273
Percent	14.66	37.13	2.65	54.45
Sample Size	94	238	17	349
Mean Length	577	605	618	598
Std. Error	3	2	9	2
Sample Size	92	238	16	346
Females	35,923	58,967	4,067	98,957
Percent	16.54	27.14	1.87	45.55
Sample Size	106	174	12	292
Mean Length	541	558	575	552
Std. Error	3	2	10	2
Sample Size	106	173	12	291
Both Sexes	67,779	139,623	9,828	217,230
Percent	31.20	64.27	4.52	100.00
Sample Size	200	412	29	641
Mean Length	558	585	600	577
Std. Error	2	1	6	1
Sample Size	198	411	28	637

Table 11. Coho salmon escapement estimates and average escapement proportions by day, Nushagak River, 1982 - 1993.

	Year											Average Proportion[a]	
Date	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993	Daily	Cum.
06/29	0	0	0	0	0	0	0	0	0	24	0	0.01	0.01
06/30	0	0	0	0	0	0	0	0	0	17	0	0.00	0.01
07/01	0	0	0	0	0	0	0	0	0	43	0	0.01	0.02
07/02	0	0	0	0	0	0	0	0	0	29	0	0.01	0.02
07/03	0	0	0	0	0	0	0	0	0	24	0	0.01	0.03
07/04	0	0	0	0	0	0	0	0	0	63	0	0.01	0.04
07/05	0	336	0	0	0	0	0	0	0	39	0	0.09	0.13
07/06	0	122	0	0	0	0	0	0	0	12	0	0.03	0.17
07/07	0	93	0	0	0	0	0	0	0	8	0	0.02	0.19
07/08	0	102	0	0	0	0	0	0	0	9	0	0.03	0.22
07/09	0	81	0	0	0	0	0	0	0	5	0	0.02	0.24
07/10	0	68	0	0	0	0	0	0	0	3	0	0.02	0.26
07/11	0	71	0	0	0	0	0	0	0	5	0	0.02	0.28
07/12	0	71	0	0	0	0	0	0	0	6	0	0.02	0.30
07/13	0	54	0	0	0	0	0	0	0	175	0	0.05	0.35
07/14	0	71	0	0	0	0	0	0	0	265	0	0.07	0.42
07/15	0	74	0	0	0	0	0	246	0	193	0	0.08	0.51
07/16	0	0	0	0	708	0	0	172	0	329	0	0.23	0.73
07/17	1,354	0	0	0	0	0	0	250	0	556	0	0.19	0.92
07/18	1,354	0	532	0	0	0	0	374	0	642	0	0.25	1.17
07/19	1,354	0	786	127	0	0	0	133	25	651	0	0.26	1.42
07/20	1,354	0	671	73	0	177	0	670	30	333	0	0.30	1.73
07/21	1,354	406	3,381	131	0	320	0	551	51	193	0	0.59	2.32
07/22	2,708	420	2,565	106	0	163	0	322	114	246	0	0.51	2.83
07/23	4,062	489	186	101	575	96	810	287	127	196	0	0.56	3.38
07/24	10,833	515	552	33	748	118	1,166	0	131	43	0	0.80	4.18
07/25	5,416	637	508	575	416	88	1,674	0	432	591	0	0.79	4.98
07/26	6,771	597	429	367	234	97	1,059	0	494	620	1,427	1.02	6.00
07/27	8,387	592	820	269	386	82	976	0	508	645	1,127	1.05	7.05
07/28	9,479	633	515	106	184	58	808	0	701	2,199	752	1.27	8.31
07/29	8,125	644	1,115	19	480	44	632	1,263	960	8,518	902	2.81	11.12
07/30	5,416	413	1,672	15	453	52	1,326	2,362	991	3,858	1,006	1.88	13.00
07/31	4,062	0	663	20	226	31	2,464	6,066	621	1,402	527	1.43	14.43
08/01	2,708	0	632	17	914	33	1,574	1,886	2,574	1,392	864	1.21	15.63
08/02	6,771	0	728	15	1,426	30	5,174	669	3,238	2,883	982	1.93	17.56
08/03	3,300	0	478	18	8,951	24	8,513	269	1,033	1,316	611	2.94	20.50
08/04	2,200	0	1,032	59	7,144	1,529	9,168	175	3,068	1,066	1,163	3.40	23.91
08/05	1,354	1,212	799	4,124	3,461	4,594	6,362	150	2,701	710	1,578	4.44	28.34
08/06	5,416	1,948	7,126	5,979	1,804	6,479	6,033	208	7,695	1,369	712	5.98	34.33

-Continued-

Table 11. (p 2 of 2)

Date	Year											Average Proportion[a]	
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993	Daily	Cum.
08/07	1,354	1,819	5,191	3,900	831	2,379	7,837	227	8,062	783	4,160	4.29	38.61
08/08	1,354	4,638	695	22,181	681	917	18,480	1,625	11,915	423	1,941	6.45	45.07
08/09	5,416	5,105	955	7,880	636	414	5,903	17,005	2,513	530	660	5.05	50.12
08/10	10,833	4,435	4,321	2,908	1,362	489	7,888	17,916	8,305	683	661	5.47	55.59
08/11	51,456	1,981	2,335	3,731	4,376	320	11,607	3,778	10,354	774	364	5.55	61.13
08/12	20,312	1,629	5,235	8,459	2,009	179	11,984	13,365	8,011	1,078	696	5.58	66.71
08/13	13,541	1,215	5,050	4,289	1,179	193	3,359	5,738	21,355	949	811	4.04	70.75
08/14	20,000	944	1,881	8,554	2,106	238	3,278	2,300	13,331	1,327	846	3.95	74.70
08/15	27,082	982	426	4,098	728	387	2,107	1,568	5,943	1,409	1,480	3.05	77.75
08/16	8,180	855	6,995	605	362	387	1,928	704	2,382	322	1,687	1.90	79.65
08/17	7,873	552	6,616	1,286	391	302	2,852	339	6,794	141	1,049	1.92	81.57
08/18	2,653		8,938	960			1,701	350	7,238	230	813	1.98	83.55
08/19			6,872	963			1,421	795	3,450	110	9,074	4.19	87.73
08/20			4,880	698			799	470	2,063	124	4,151	2.21	89.95
08/21			5,463	156			911	352	1,301	37	1,129	1.15	91.10
08/22			26,267				1,016	291	1,078		693	4.04	95.14
08/23			15,314				291	195	864		415	2.35	97.49
08/24			5,782					1,275	694		342	1.57	99.06
08/25			4,435					282	557		119	0.94	100.00
08/26								78	808				
08/27									2,801				
08/28									2,130				
08/29									1,662				
08/30									1,458				
08/31									848				
09/01									722				
09/02									484				
09/03									602				
09/04									1,011				
09/05									831				
09/06									1,064				
09/07									1,283				
09/08									984				
09/09									1,289				
09/10									1,373				
09/11									1,512				
09/12									287				
Total	263,832	33,804	142,841	82,822	42,771	20,219	131,101	84,706	162,853	39,598	42,742		

[a] Average Proportions for 1982 - 1991, 1993, June 28 through August 25.

Table 12. Age, sex, and size composition of coho salmon escapement, Nushagak River sonar project, 1993.

	Age Group		
	2.1	3.1	Total
Males	19,691	720	20,411
Percent	46.07	1.68	47.75
Sample Size	82	3	85
Mean Length	539	586	541
Std. Error	6	26	6
Sample Size	82	3	85
Females	22,091	240	22,331
Percent	51.68	0.56	52.25
Sample Size	92	1	93
Mean Length	555	603	556
Std. Error	4		4
Sample Size	90	1	91
Both Sexes	41,782	960	42,742
Percent	97.75	2.25	100.00
Sample Size	174	4	178
Mean Length	548	590	549
Std. Error	4	26	4
Sample Size	172	4	176

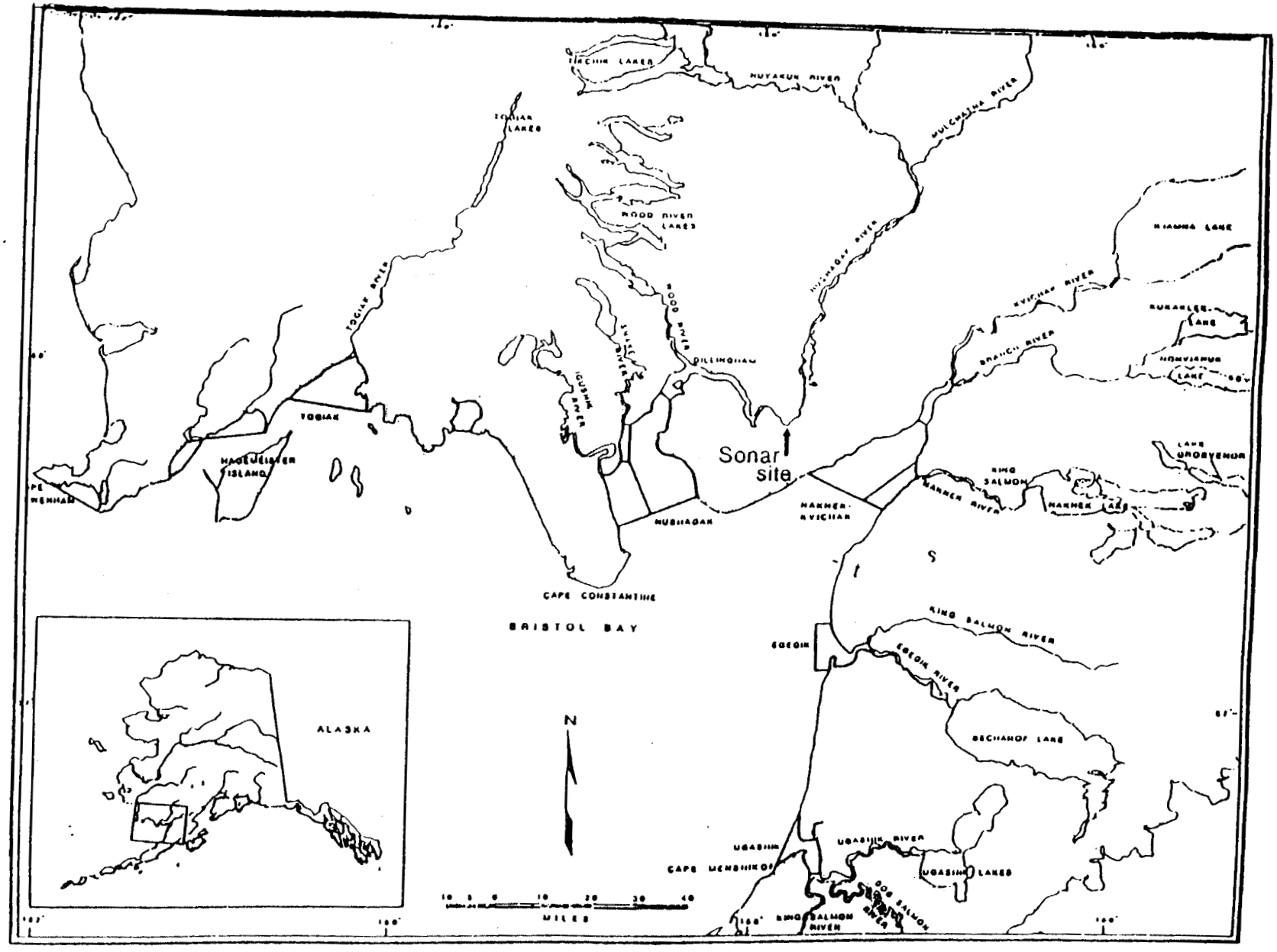


Figure 1. Bristol Bay area with location of Nushagak River sonar project site.

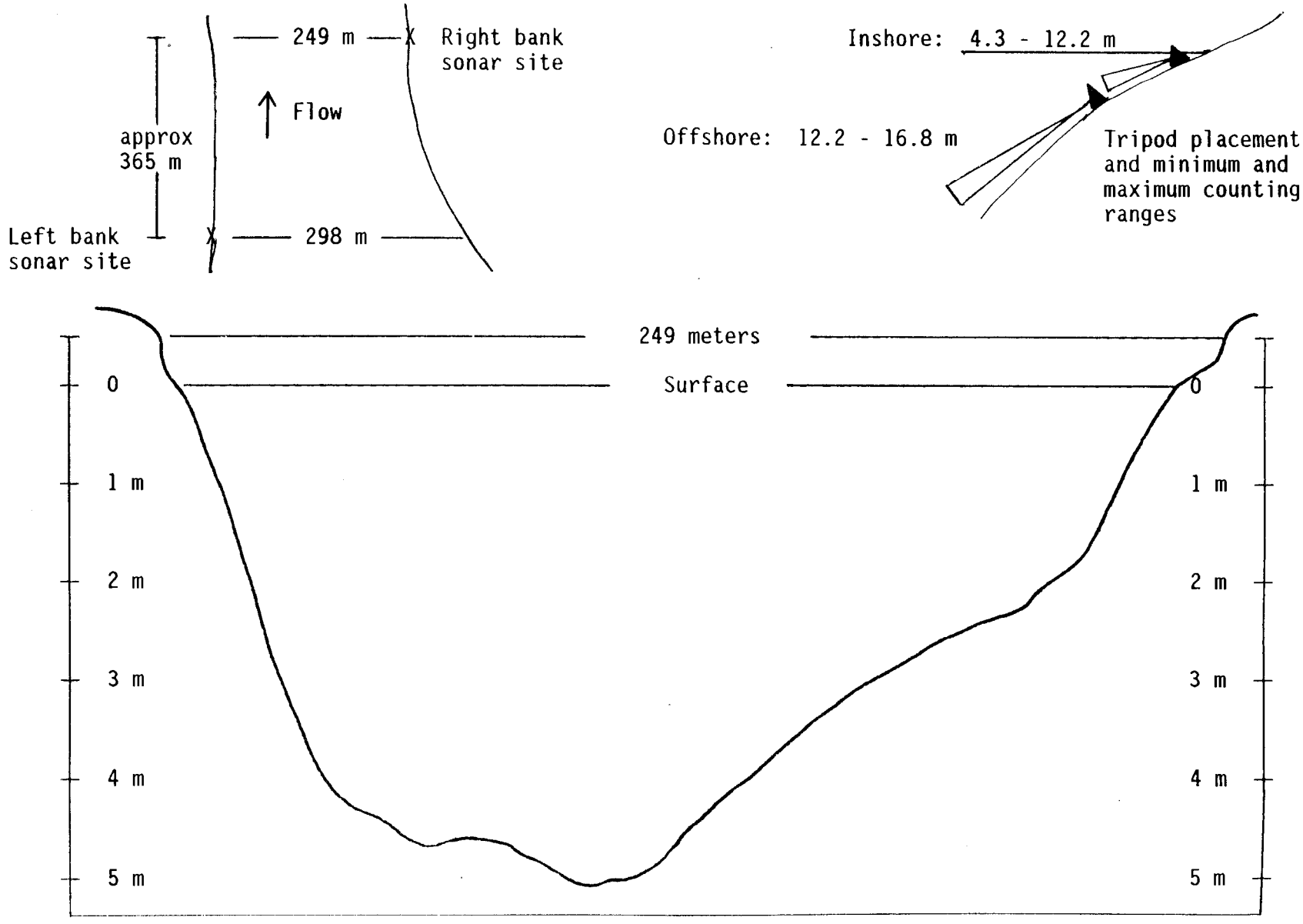


Figure 2. Detailed right bank sonar placement, relationship to left bank sonar, and bottom profile of Nushagak River at right bank sonar site, 1993.

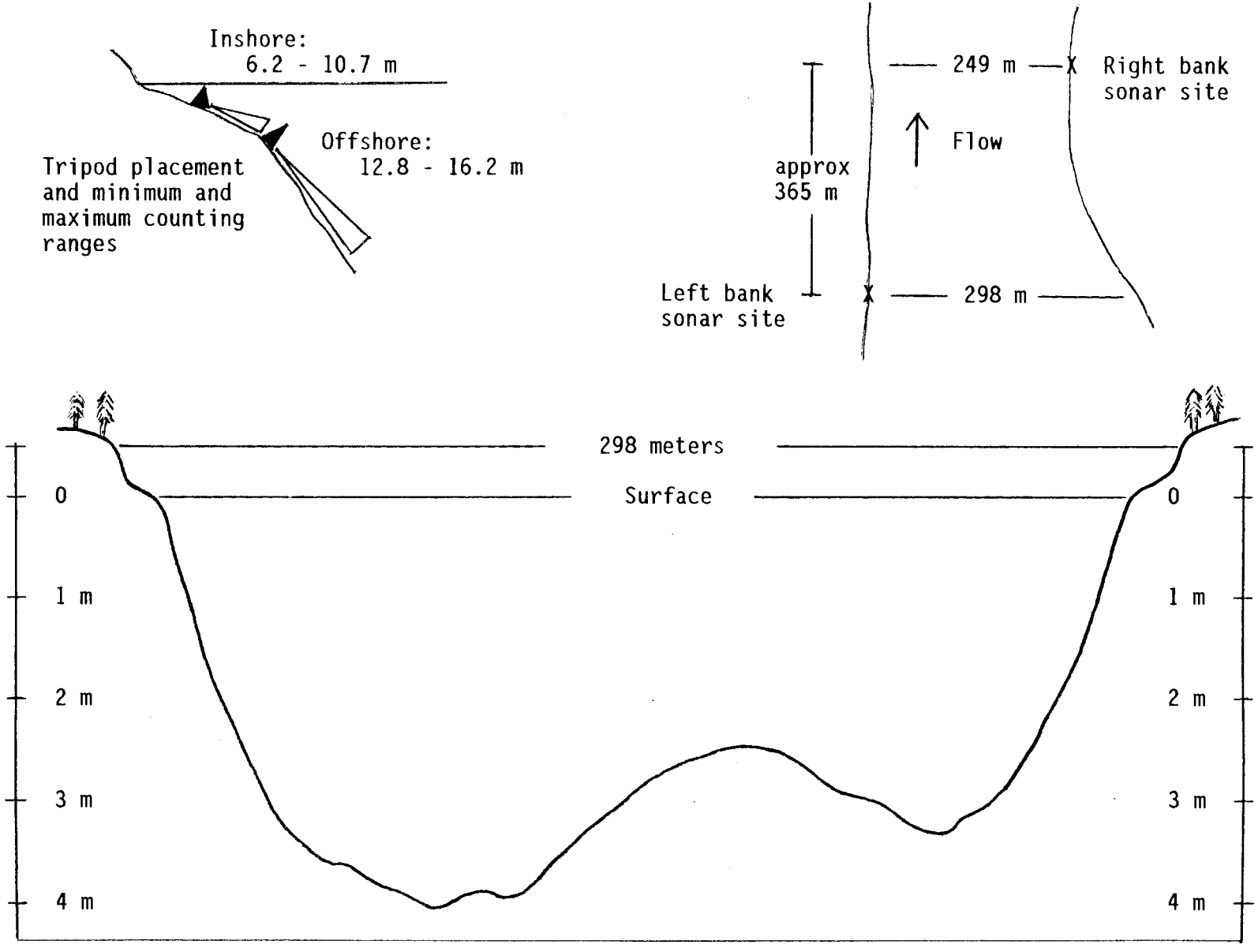
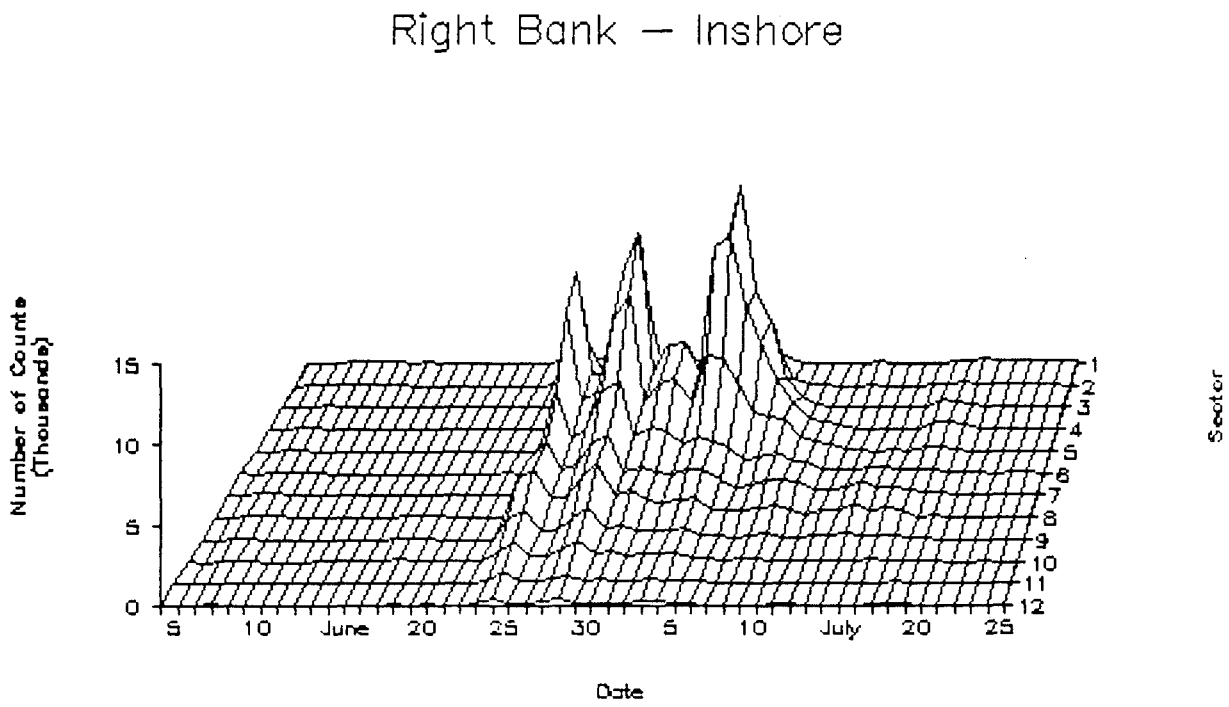


Figure 3. Detailed left bank sonar placement, relationship to right bank sonar, and bottom profile of Nushagak River at left bank sonar site, 1993.



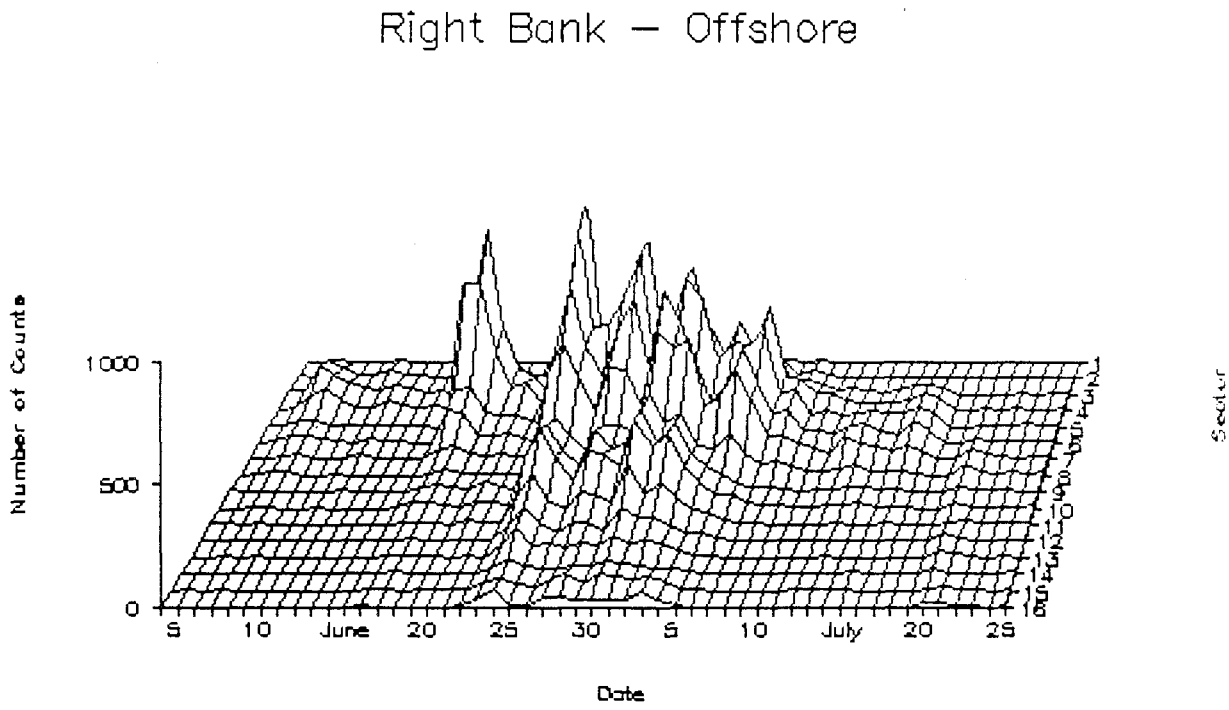
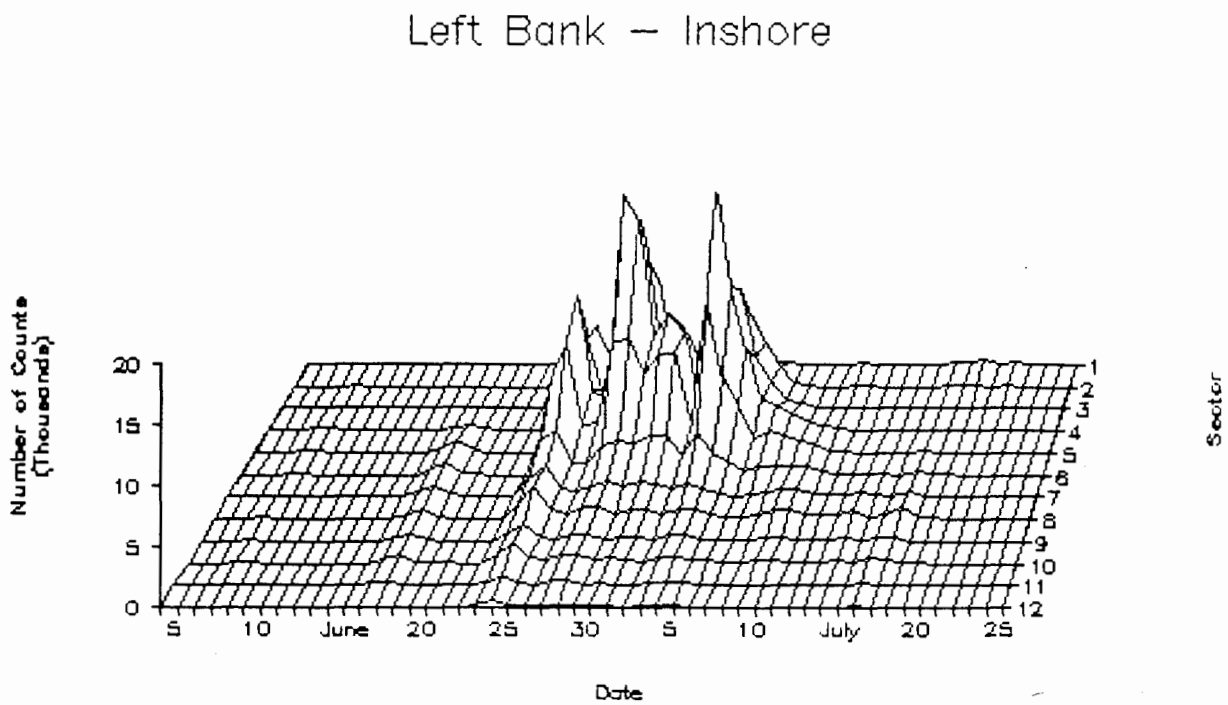


Figure 4. Number of sonar counts by sector for the right bank inshore and offshore counters, Nushagak River sonar project, June 4 - July 25, 1993.



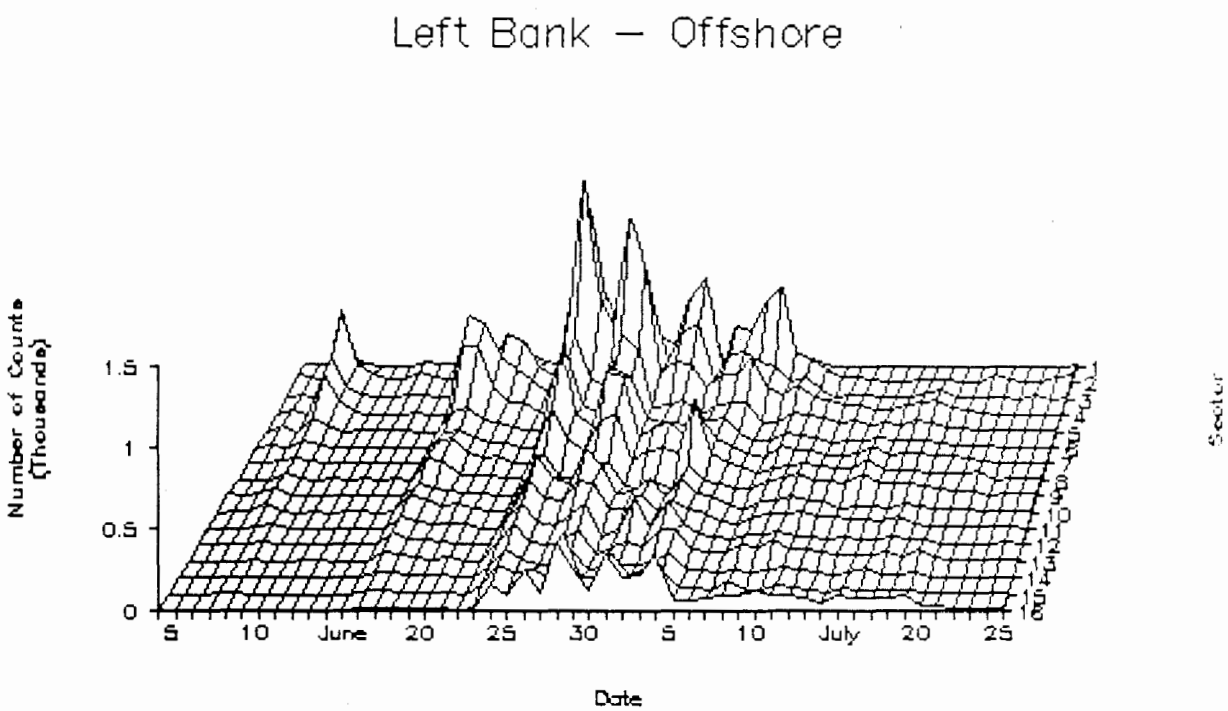
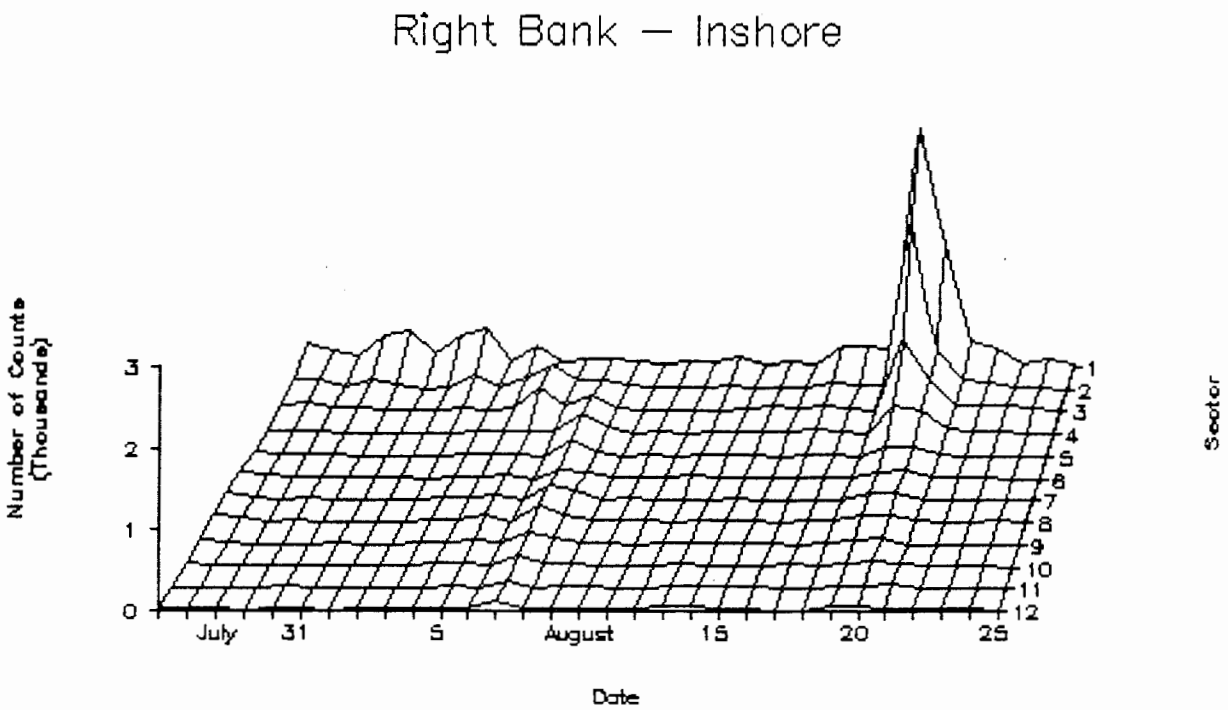


Figure 5. Number of sonar counts by sector for the left bank inshore and offshore counters, Nushagak River sonar project, June 4 - July 25, 1993.



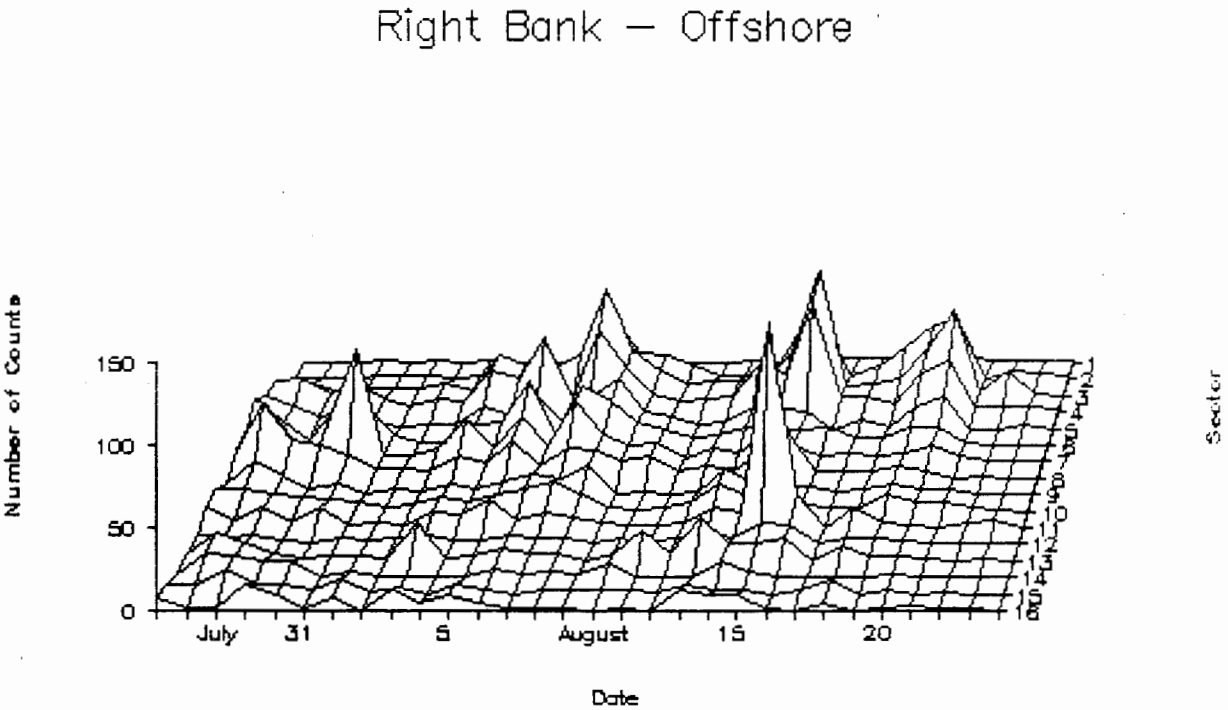
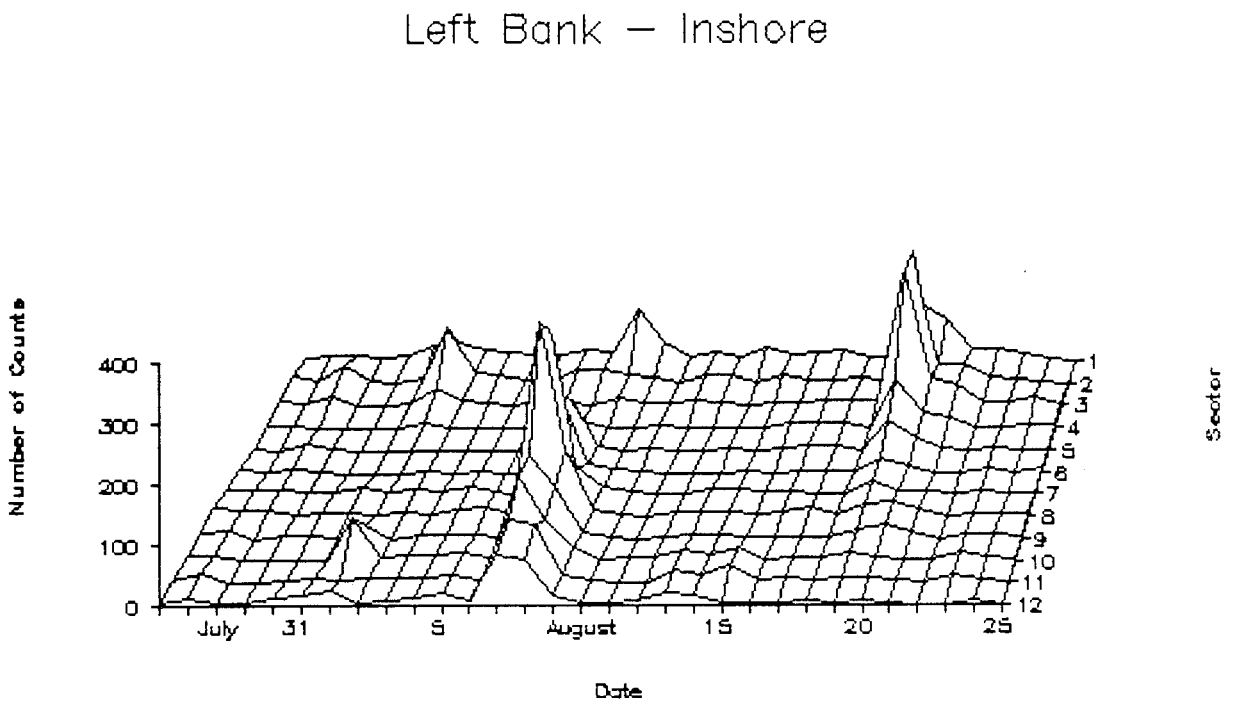


Figure 6. Number of sonar counts by sector for the right bank inshore and offshore counters, Nushagak River sonar project, July 26 - August 25, 1993.



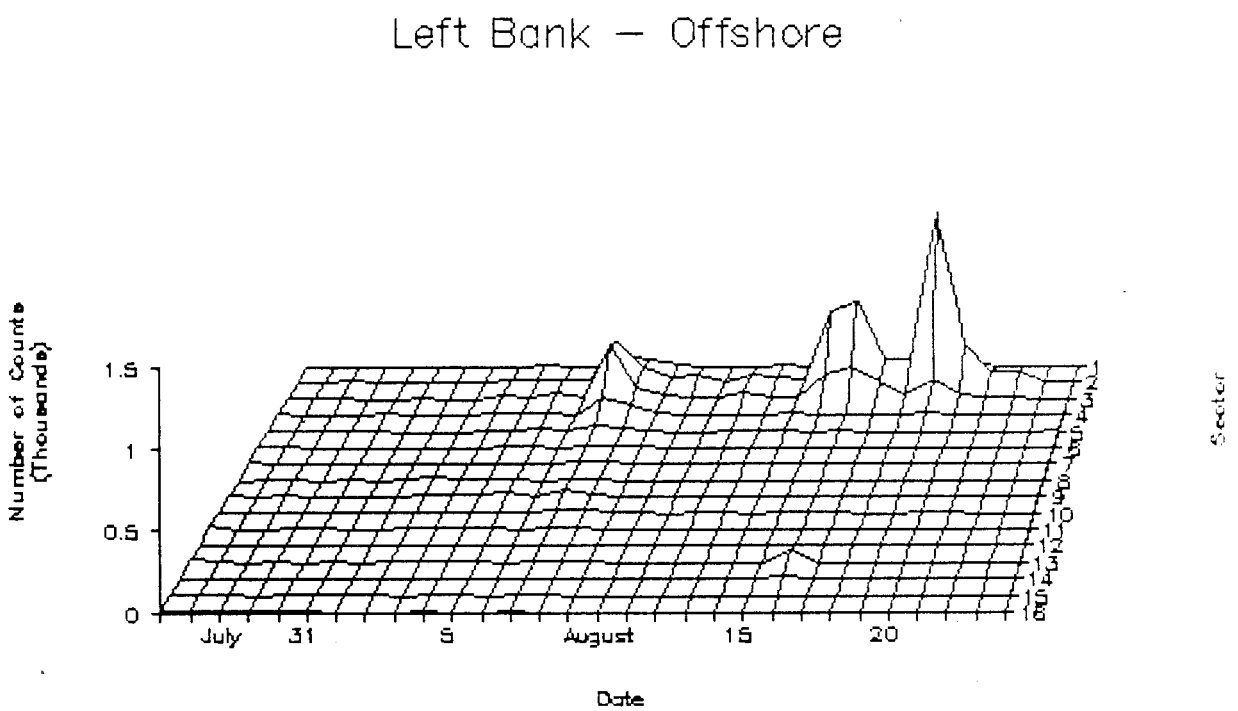


Figure 7. Number of sonar counts by sector for the left bank inshore and offshore counters, Nushagak River sonar project, July 26 - August 25, 1993.

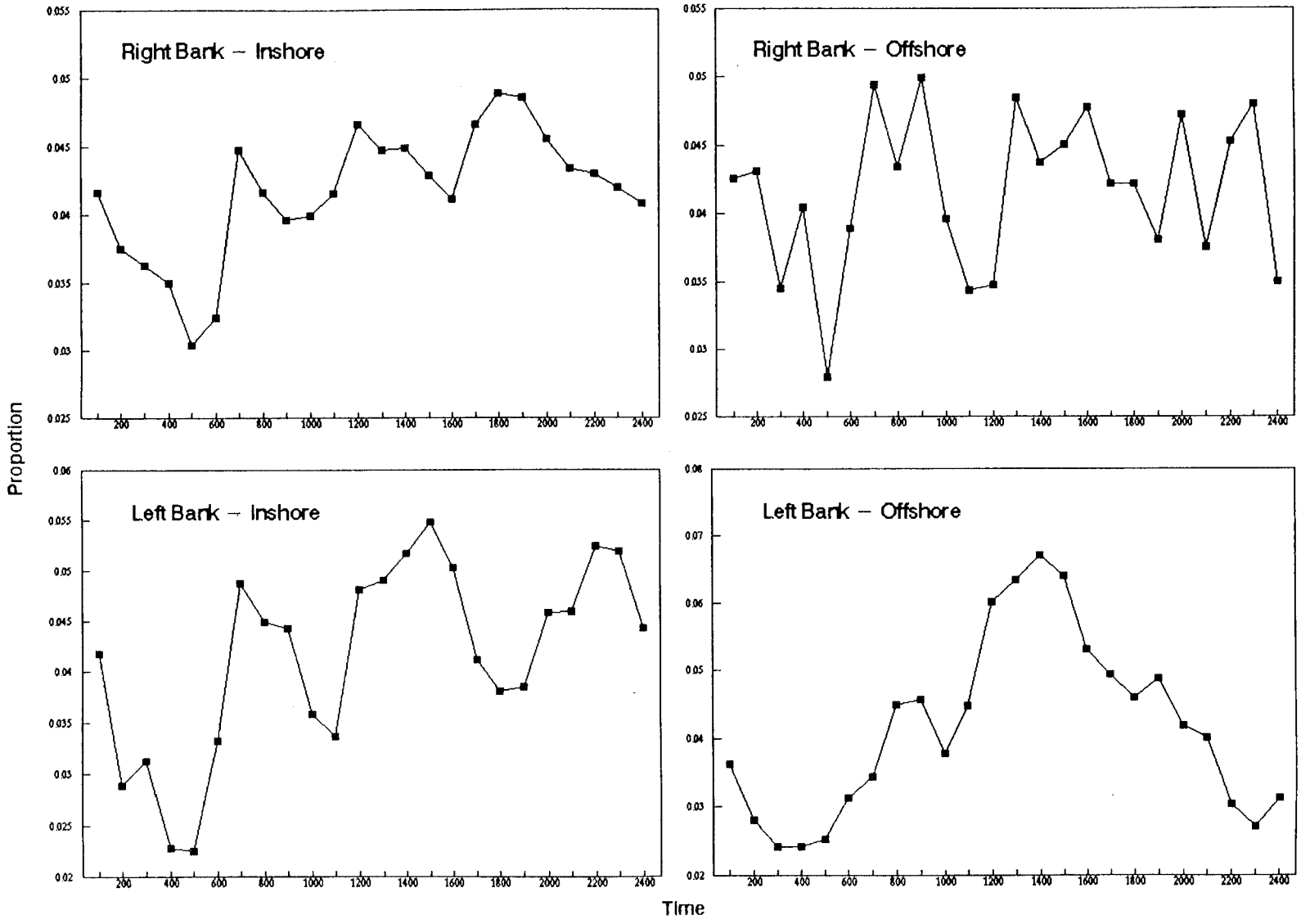


Figure 8. Proportion of sonar counts by hour for the right and left banks inshore and offshore counters, Nushagak River sonar project, 1993.

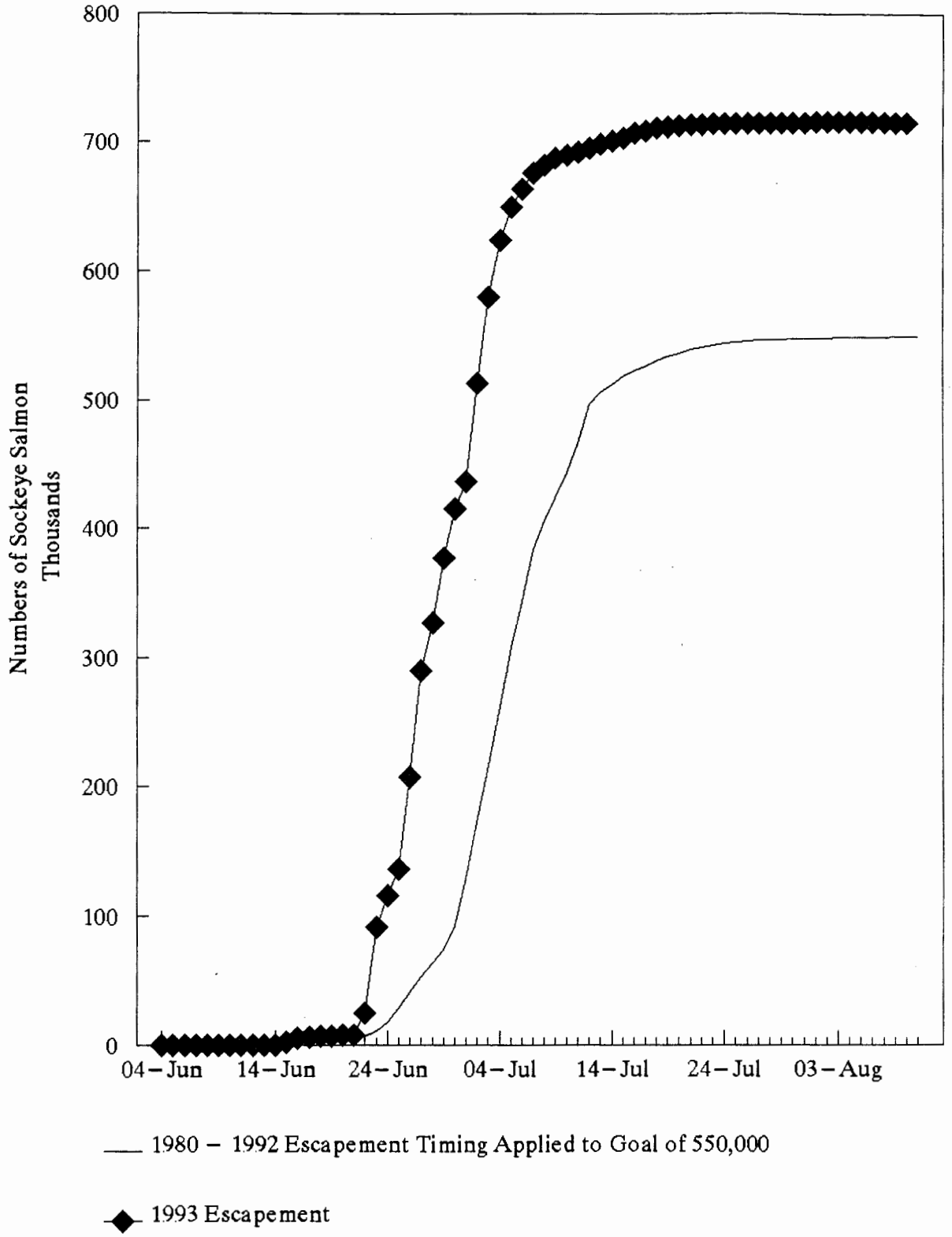


Figure 9. Average escapement timing of sockeye salmon into Nushagak River, June 4 through August 10, 1980 - 1993.

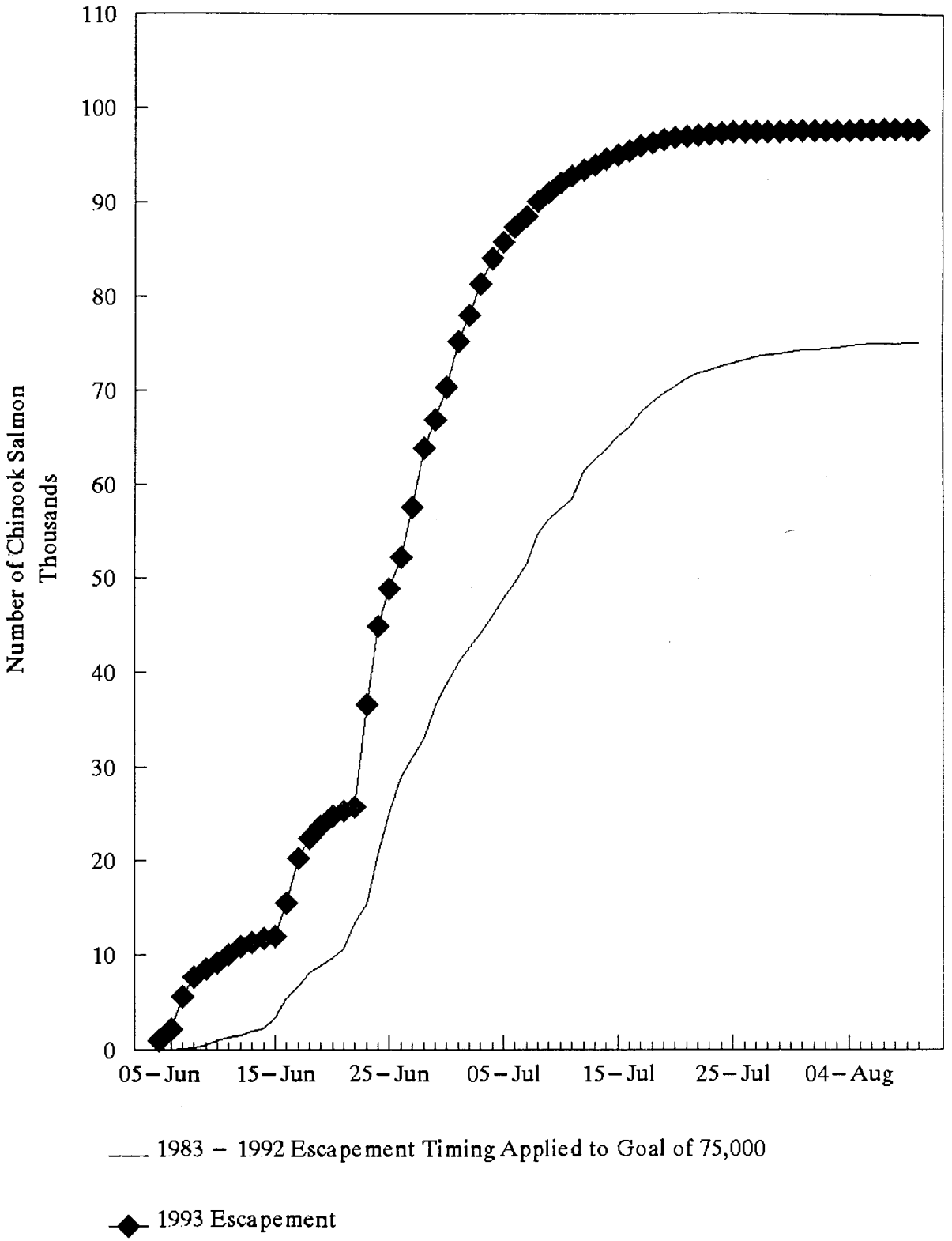


Figure 10. Average escapement timing of chinook salmon into Nushagak River, June 5 through August 10, 1983 - 1993.

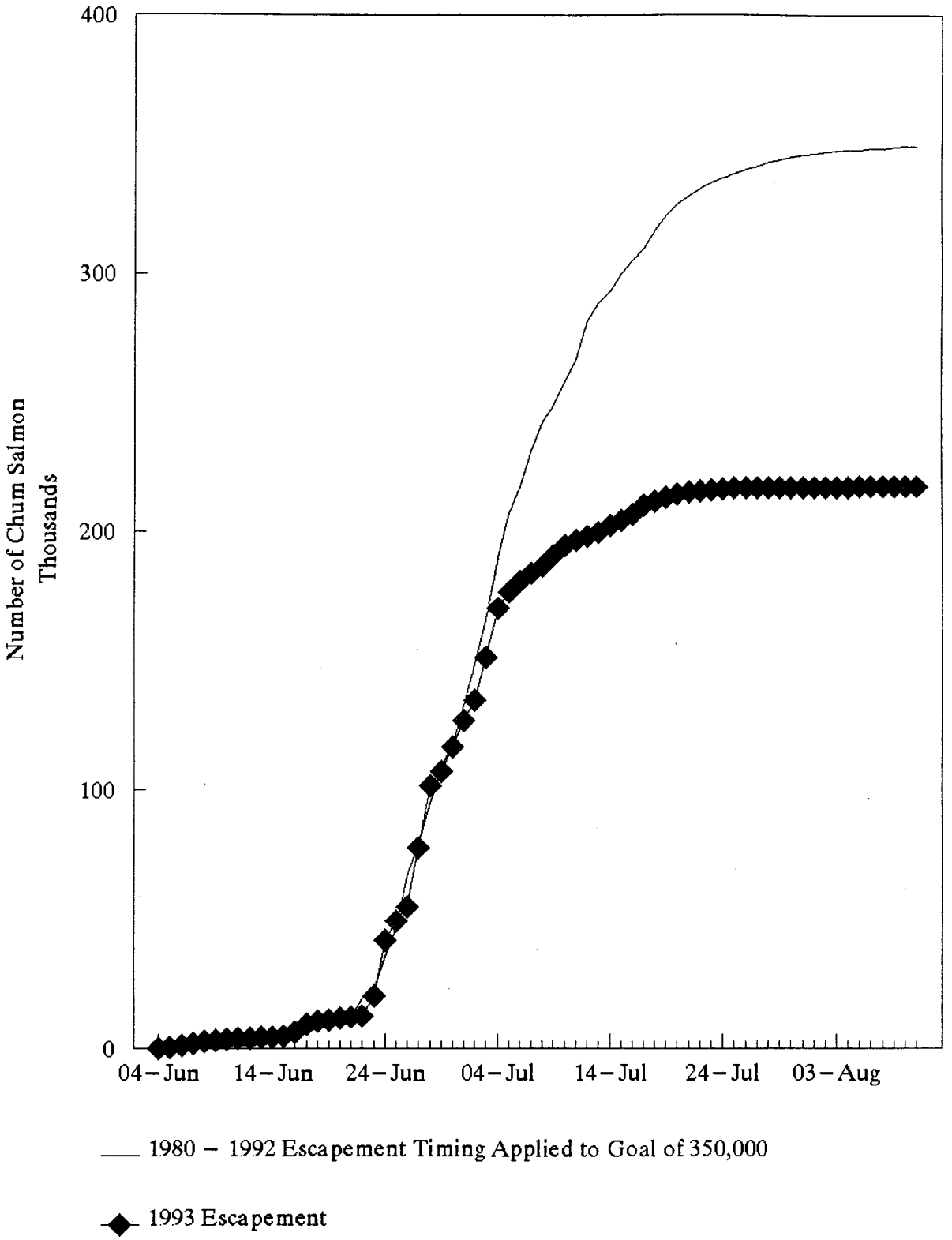


Figure 11. Average escapement timing of chum salmon into Nushagak River, June 4 through August 10, 1980 - 1993.

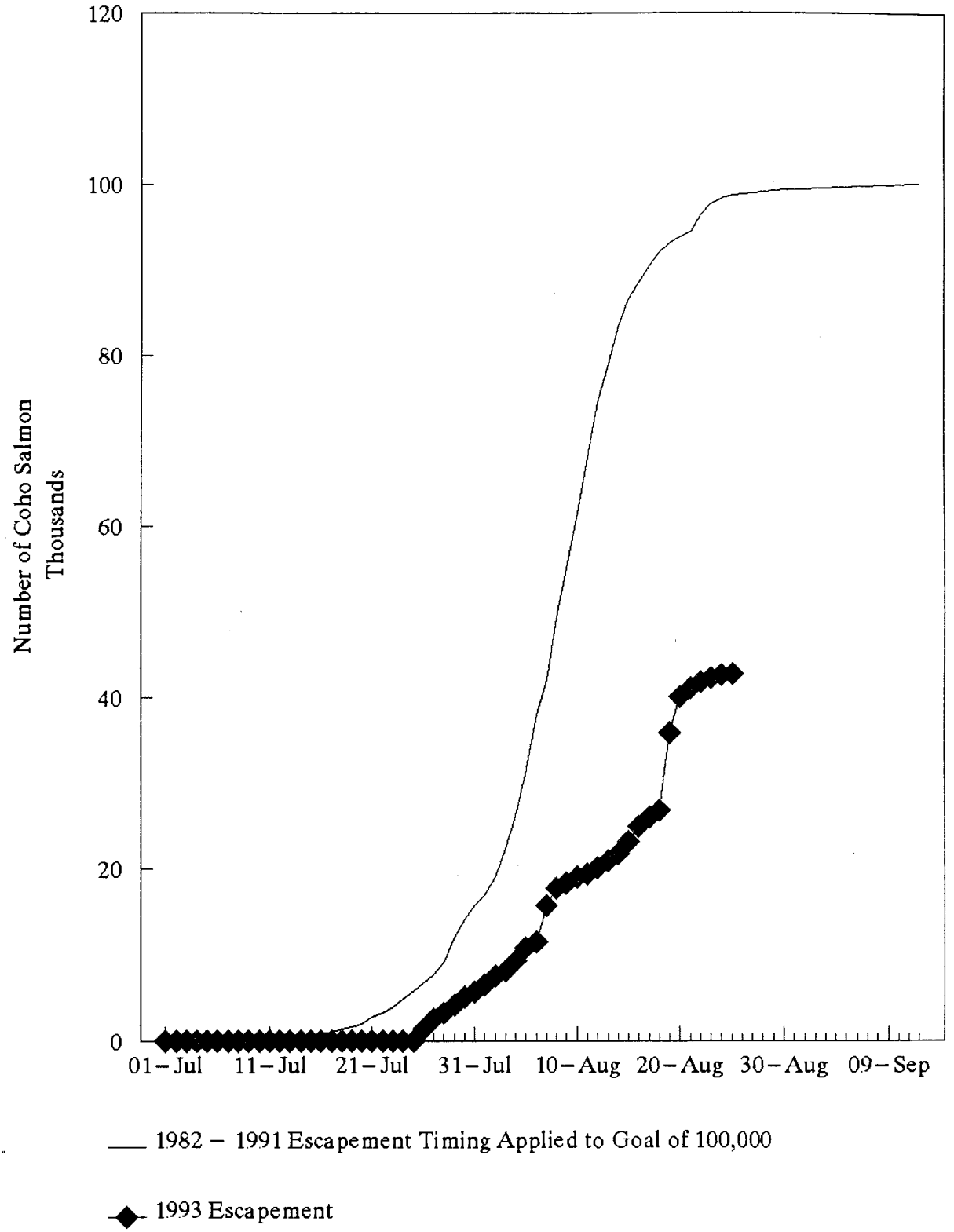


Figure 12. Average escapement timing of coho salmon into Nushagak River, July 1 through September 12, 1982 - 1993.

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